TRUMPF

PFG-RF

Operating instructions PFG-RF

RF Generators

Notice!

This operating manual is required for the safe operation of the RF Generator PFG-RF. Therefore, you should keep the operating manual close to the unit.

Operating instructions PFG-RF 23.07.2007
Item No.: A 04-0059-00.BEN-001-19

Who are these operating instructions for?

This manual is intended for all persons who are working with and on the RF Generator PFG-RF, and especially for the operating personnel.

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This manual contains the most precise description of the product possible. However, this does not guarantee particular features or application results. We are always grateful for criticism or hints regarding imperfections, and suggestions for possible improvements.

Unless otherwise stated, the relevant State of Engineering is that at the time of combined delivery of the product and the manual by HÜTTINGER Elektronik GmbH & Co. KG. The product is subject to technical changes without prior notice. Previous manuals are no longer valid.

Do you have any questions? Or problems with installation and operation? - Call us! We will be glad to help you.

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Chapter Outline:

Who is this chapter directed at?

This chapter is intended for all persons who install, operate, and maintain RF Generator PFG-RF on the basis of this operating manual.

Chapter contents

This chapter contains the principal details of the product and the operating manual.

1.1 GENERAL DETAILS OF THE PRODUCT

The present operating manual applies to the following units:

RF Generator PFG-RF

Manufacturer:

HÜTTINGER Elektronik GmbH + Co. KG
Bötzinger Str. 80
D-79111 Freiburg
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E-mail: info@de.huettinger.com
Internet:http://www.huettinger.com

1.2 WARRANTY

The duration of the warranty is specified in the **order confirmation** and in the **general terms and conditions of sale and delivery of HÜTTINGER Elektronik GmbH + Co. KG** .

Damage caused by improper use or unauthorized modification of the device does not constitute grounds for a warranty claim.

1.3 STRUCTURE OF THE DOCUMENTATION

GENERAL

There are two types of accompanying documents for Hüttinger products:

- Operating manual
  - The operating manual provides all necessary details for the installation, operation and maintenance of the respective systems.
- Technical documents regarding the unit
  - The technical documents regarding the unit provide detailed plans, drawings and lists for the unit. This information is not meant for operating personnel. Service, maintenance and repair guided by these documents must be carried out by specially trained skilled personnel only.

This document is the **operating manual**.

STRUCTURE OF THE OPERATING MANUAL

The present operating manual consists of eight chapters which contain all necessary information for the operation of the system:

- Chapter 1: "STRUCTURE OF THE DOCUMENT"
- Chapter 2: "SAFETY"
- Chapter 3: "DESCRIPTION, TECHNOLOGY"
- Chapter 4: "VERSIONS, ACCESSORIES"
- Chapter 5: "INSTALLATION"
- Chapter 6: "OPERATION, CONTROL"
- Chapter 7: "MAINTENANCE"
- Chapter 8: "INTERFACES"

STRUCTURE OF THE INDIVIDUAL PAGES

Header

A product symbol is located at the top outside corner of the page so that it is straight-forward to recognize the product to which the operating manual applies.

Footer

The footer contains information about the actual chapter:

- chapter number and name,

- document name

The current chapter is indicated by a pictograph above the page number which contains the chapter number and corresponding symbol.

Explanation of pictograms and symbols

Danger !

This sign warns of possible personal injury. Serious and even fatal injuries could result if this sign is not heeded.

Life Threatening Voltage !

This sign warns of danger from electrical voltage. If not heeded, electrical shocks and their known, even fatal, consequences could result.

Warning !

This sign warns of dangers for the product. Damage and even complete destruction of the product and adjoining parts can result if this sign is not heeded.

Warning: Electromagnetic fields !

This symbol warns of electromagnetic fields.

Danger: High frequency !

These signs warn of danger from high frequency radiation. Persons with pacemakers or implants may not enter areas where this sign is posted as pacemaker operation can be disturbed by the presence of high frequency radiation and implats can heat-up.

Notice !

This sign draws attention to important information.

Symbol of work step instructions

This symbol calls your attention to tasks which are to be carried out.

1.4 TECHNICAL EXPRESSIONS AND ABBREVIATIONS

DESCRIPTION OF THE ABBREVIATIONS

AV	Actual value
NV	Nominal value
P_I	Forward power (incident power)
P_R	Reflected power
U_B	Operating voltage of the power output amplifier
U_{DC}	DC BIAS voltage
U_{DS}	Drain source voltage
RF_{PEAK}	RF peak voltage
I	Operating current
I_{10}	Pre-amplifier current
C_T	Position of the capacitor C-Tune
C_L	Position of the capacitor C-Load
T	Duty cycle

2 SAFETY

Chapter Outline:

Who is this chapter directed at?

This chapter is intended for all persons who install, operate, and maintain RF Generator PFG-RF on the basis of this operating manual.

Chapter contents

The chapter contains the principal details for the safe operation of the product.

2.1 INTENDED USE

Danger!

The protection of operating personnel and the system is not guaranteed if the generator is not operated in accordance with its intended use.

The generator may only be operated by qualified personnel in accordance with these operating instructions.

FUNCTION AND OPERATION OF THE EQUIPMENT

Generator

The generator is an electrical device which converts mains alternating voltage into high-frequency alternating voltage.

Intended use

Typical applications, intended use

The generator supplies a high-frequency alternating voltage at its output. It is used to excite various plasma and thin layer processes, such as, e.g.

- magnetron sputtering
- sputter-etching
- reactive ion etching
- CVD plasma processes
- BIAS applications

Unauthorized operating method

The generator may only be used within the scope of its intended use. Unauthorized use refers particularly to

- medical science purposes,
- broadcasting purposes,
- environments where a danger of explosion exists,
- use as a mobile device.

If you would like to use the generator in other applications than plasma and thin layer processes, please ask HÜTTINGER in advance.

2.2 GENERAL WARNING NOTICES

DANGERS IN THE UNIT'S OPERATIONAL PREMISES

When operated as intended, there is no danger to persons resulting from the emission of high-frequency fields. Design measures ensure compliance with the EC directives (including the EMC directive implementing the emission limits according to EN 55011).

During certain service work, however, higher field strengths than normal may occur. Similarly, in the case of malfunction, high-frequency fields with amplitudes in excess of the above limits may occur.

Only in these cases there may be a hazard to persons with active or passive health aids (pacemakers, implants). To eliminate dangers to these persons at all times, the following notice is to be observed:

Danger: High frequency!

Alternating electromagnetic fields can have an unwanted, damaging effect on active and passive health aids (pacemakers, implants...). Persons with active and passive health aids must not be present in the area affected by the unit.

- *Affix the adhesive signs "No entry for persons with pacemakers" at all entrances to the room the unit operates in. The signs are shipped with the unit.*

DANGEROUS HIGH VOLTAGES

Life Threatening Voltage!

The generator converts low frequency, mains electricity into high frequency electrical energy. High voltages encountered here are definitely life-threatening!

- *Never open the generator while it is connected to mains.*

WARNING SIGN

Secure the provided metal sign with the four symbols near the inductor coil.

Warning!

If the generator is used outside the scope of the specifications (see section "Technical Data" in chapter 3 "Description, Technology"), the safety of the generator can no longer be guaranteed.

DANGEROUS MATERIALS

Danger!

The following dangerous materials and fuels are used in the generators which could be released in the event of destruction of structural components:

- Beryllium oxide in the RF transistors and in the RF power resistors

2.3 PERFORMING WORK

QUALIFIED PERSONNEL

Warning!

All work on the generator must only be carried out by persons with the proper training and professional experience. Also required is the ability, based on knowledge of the relevant application, to evaluate and carry out the necessary work and recognize the possible dangers.

2.4 DANGER AREAS: MAINTENANCE AND REPAIR

DANGER AREAS: MAINS SUPPLY SWITCHED OFF

Life Threatening Voltage!

Even with the main switch Q1 switched off, the following parts still carry mains voltage:

- mains connection
- wiring up to the main switch Q1

Separate the generator from mains in order to make these components voltage-free (disconnect).

Life Threatening Voltage!

Even if the device is disconnected, there may also be residual DC voltages that, in the case of a fault, may be of the same magnitude as their operating values.

This may be the case:

- At the operating power supply (46 V), a residual voltage of < 60 V may be present for > 5 s.

2.5 SAFETY DEVICES

MONITORING AND PROTECTION DEVICES

Notice!

You, as the operator, are responsible for the safe operation of the generator. It is your responsibility to become accustomed with the applicable legal regulations and to apply them.

Personal protection in the case of induction

For induction applications the coil must be protected from physical contact, as dangerous RF voltage is present during generator operation.

Interlock input

An interlock input (Interlock 1) is available to externally switch off the output power of the generator.

Interlock 1

Interlock 1 switches the power relay off. It must be wired without potential (via the A/D interface). The output voltage is switched off when the external safety switch connected to Interlock 1 is opened. Several safety switches may be connected in series to replace a single switch.

Attention!

The Interlock does not guarantee personal safety and, therefore, cannot be used as an emergency-power-off switch.

Life Threatening Voltage!

When a protection device triggers at the Interlock, only the power relay is switched off. The generator still carries voltage.

Interlock outputs

In order to switch off external devices by the generator, two floating interlock outputs (Interlock 2, Interlock 3) are available to you.

Interlock 2

Interlock 2 is designed as a normally closed contact and is switched via the power relay. When the generator outputs power, this contact is open. When the generator does not output power, this contact is closed. Interlock 2 is only present for the generators PFG 1600 … 5000 RF.

Interlock 3

Interlock 3 is designed as a normally open contact, and is switched via the power relay. When the generator outputs power, this contact is closed. When the generator does not output power, this contact is open.

System protection

For the protection of the generator and other connected devices, the generator switches off the output power immediately in case of

- excess temperature
- open Interlock1 circuit

The generator switches the output power off with delay in case of persistent

- overcurrent of the final stage
- mismatch (P_R > 20 % P max)
- overvoltage at the final stages (U_{DS} > 110 V)
- defective final stage
- operating current > 20 A (PFG 300 RF: > 8 A) and P_R > 50% P_I

See also chapter 6.6: "Troubleshooting, rectification of faults"

2.6 MEASURES IN CASE OF EMERGENCY

In an emergency, carry out the following steps in the given order:

1. Switch off the external mains separation device for the generator.
2. Turn off the cooling water supply for the generator.
3. Put out any fires with a suitable extinguisher.

Life Threatening Voltage!

Due to the high voltages present, never extinguish the fire with water.

3 DESCRIPTION, TECHNOLOGY

Chapter Outline:

Who is this chapter directed at?

This chapter is intended for all persons who install, operate, and maintain RF Generator PFG-RF on the basis of this operating manual.

Chapter contents

The chapter contains information about the functionality and technology of the RF Generator PFG-RF, their use, fields of application, and technical data.

3.1 CLASSIFICATION ACCORDING TO EN 55011

The EN 55011 standard groups ISM devices (industrial, scientific and medical high-frequency devices) into various groups and classes.

The RF Generator PFG-RF are devices of **Group 2 / Class A**.

Group 2 includes all ISM devices, where HF energy is purposely generated and / or used as electromagnetic radiation for the treatment of material.

Devices of Class A are intended for operation in an industrial environment. The electromagnetic compatibility in other environments (residential areas) may not be guaranteed due to the conductor-bound interference factors that occur.

3.2 COMPONENTS, DEVICE OVERVIEW

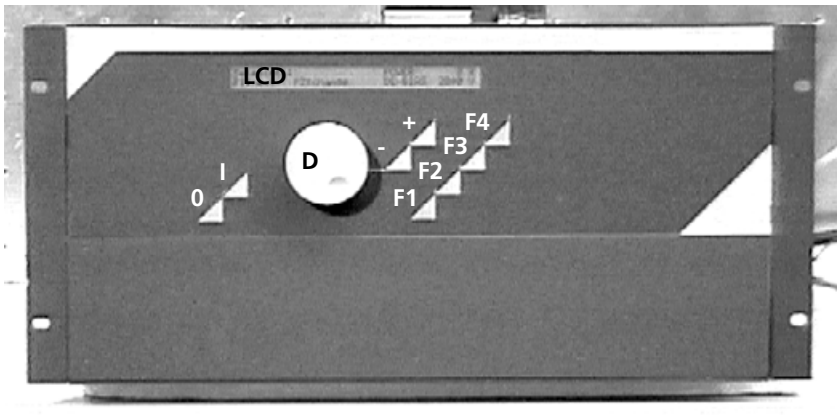


Fig. 3.1 Front side (using the PFG 1600 RF, PFG 2500 RF as an example)

The following controls are located on the front of the controller:

- LCD display (LCD)
- ON button (I)
- AFF button (0)
- Rotary button (D)
- Incremental keys (incremental key +, decremental key -)
- Function keys (F1 … F4)

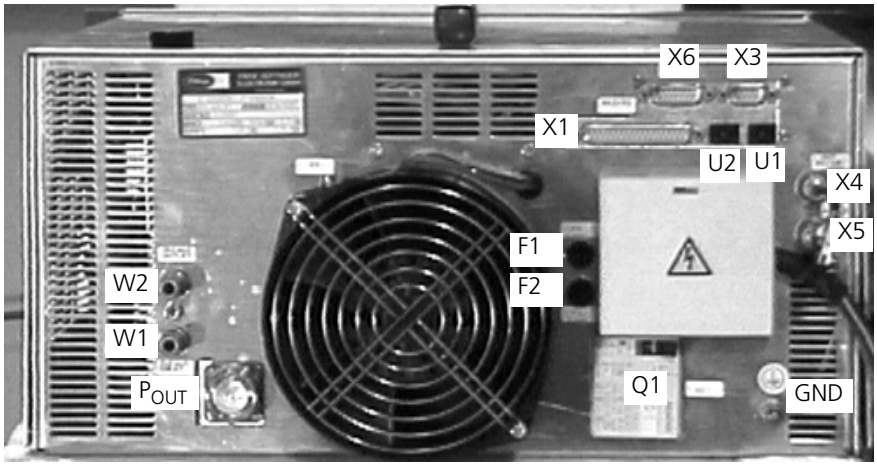


Fig. 3.2 Rear side (using the example of PFG 1600 RF, PFG 2500 RF)

The following operating elements, interfaces and connections are located at the rear:

- Main switch (Q1)
- A/D-interface (X1)

- Mains connection with protective cover (X2)
- RS 232 C interface (X3)
- RF output (X4)
- RF input (X5)
- RF power output (P_{OUT})
- RS 485 interface (X6)
- Fiber optic cable IN (U2), fiber optic cable OUT (U1)
- Earth connection (GND)
- Fuses (F1, F2)
- Cooling water connection inflow (W1), outflow (W2)

The interface equipment of your generator is stated in the document "Technical Specification".

Block diagram

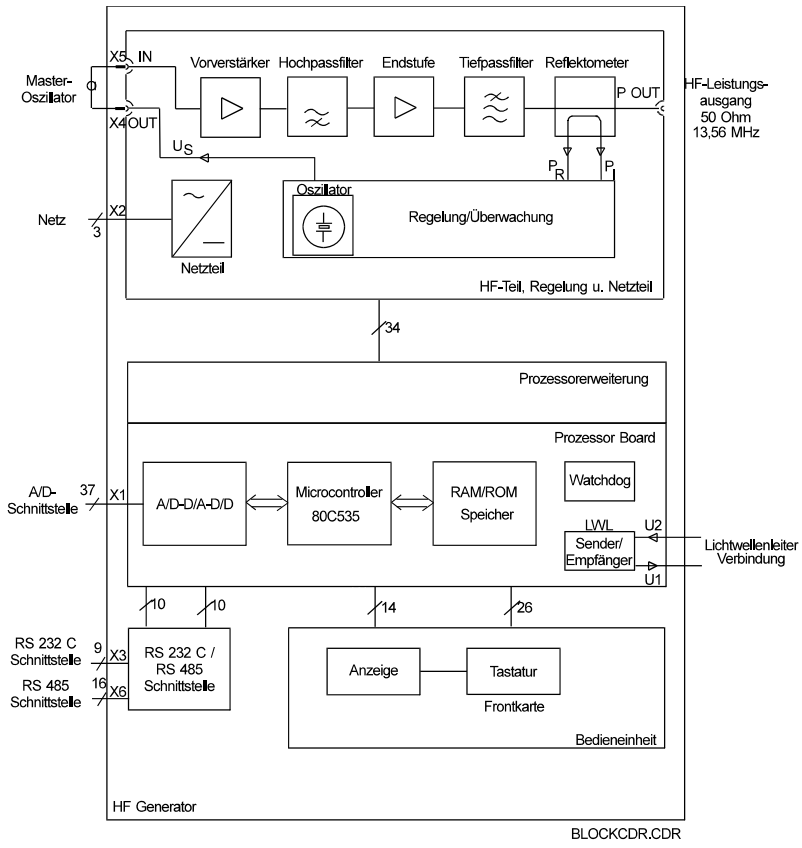


Fig. 3.3 Block diagram of generator

3.3 TECHNOLOGY

The HÜTTINGER RF generators of the PFG-RF series are fully transistorized and µC-controlled RF generators that recommend themselves for their robustness, reliability and easy maintenance.

The protection against mismatches and overload, which is particularly important in plasma technology applications, is given by overdimensioning in conjunction with electronic monitoring and protection circuits.

The generator operated via a keypad with function keys and a double-line LCD display. All functions can be remote controlled via interfaces (A/D interface, serial interfaces RS232-C and RS485, fiber optic cable interface, optional Profibus interface). Therefore, the generator can very easily be integrated into a process computer controlled system.

The generator requires a matching network in order to be operated.

The generator may be used in synchronous operation mode (several synchronous generators). For synchronous operation mode, a master oscillator is required.

Furthermore, one generator may supply different process stations via an RF selector switch.

The communication with the other HÜTTINGER components (matching network, RF selector switch) is accomplished via an optical fiber ring bus. This prevents interference on the communication channel caused by EMC.

(refer also to chapter 4: "Variants, Accessories".)

3.4 FIELDS OF APPLICATION

The generators may be used for all PVD and CVD processes as well as for ion etching processes in the area of plasma and thin layer technology. Advantages result in particular during sputtering in 'reactive mode' and when creating insulating layers.

3.5 CONTROL

Setting the RF power

The adjustment of the RF power is continuous from 0.5-100% in steps of 1 W (10 W for PFG 5000 RF) by varying the control voltage of a ring mixer in the quartz oscillator.

2-channel regulation

The generators have a 2-channel regulation. For this, 2 values are specified: a nominal value and a value to be limited. The regulator regulates towards the nominal value specified. However, if the limited value has reached its limit, the regulation switches and keeps the value at the limit. As soon as the value moves back below its limit, the regulation switches back and regulates towards the specified nominal value.

With such a 2-channel regulation, dangerous operational states can be largely avoided. However, the user is expected to input a limit in addition to the nominal value.

If the nominal value is a power, then the limit is always a voltage, and vice versa (depending on the type of regulation).

Example (regulation: DC-BIAS, limit: P_I)

When the RF power is switched on, the plasma in the system has not yet ignited. Hence, no DC BIAS voltage U_{DC} is present, i.e., $U_{DC} = 0$. With immediate regulation towards U_{DC}, the generator would be driven towards the upper limit of its power rating and would remain there until the plasma has ignited and thus creates a DC BIAS voltage. Only then, the regulator could give the appropriate control signal for the adjustment of the RF power, which generates the desired DC BIAS voltage.

Such a behavior of the generator is, however, undesired in the case of most plasma processes. It may even be detrimental to the product if an excessive RF power is present at the electrodes for a brief period.

Switching on the power

When the power is switched on, the regulator thus regulates first with respect to the forward power P_I in each operation mode, such that the generator is only driven up to the limit $P_{I\,max}$ that is preset there. Regulation is directed towards this power until such time as the plasma ignites.

Plasma ignites

- If the plasma thus created only requires a lower RF power than the specified limit $P_{I\,max}$, regulation switches over to DC-BIAS regulation and the RF power is limited to a smaller value, such that the specified nominal value for U_{DC} can be maintained.
- However, if the plasma requires a higher RF power than the preset nominal value for the limit P_i , this nominal value must be corrected upwards until a change to DC-BIAS regulation is made.

In each case, the circuit selects the smaller of the two signals as the control quantity.

Modes of regulation

Modes of regulation

The generators are equipped with the following modes of regulation:

- POWER regulation
- DELTA-P regulation
- DC BIAS regulation
- RF PEAK regulation

In the case of POWER and DELTA-P, the regulator regulates towards a power, in the case of DC-BIAS and RF-PEAK, it regulates towards a voltage.

The regulation modes are described in the following sections.

Regulation with respect to power

Notice!

If no voltage limitation is used, the limits U_{DC} or RF_{PEAK} must be set to the maximum value!

POWER regulation

The POWER regulation is the generator's default regulation. In this case, the forward power P_l of the generator is regulated. The currently preset nominal power value P_l is used as the guiding quantity.

DELTA-P regulation

DELTA-P regulation regulates the output power. The aim of this regulation is to keep the power in the system (i.e., in the plasma chamber) constant. The power delivered by the generator is the sum of the currently preset nominal power value and the current reflected power. If, e.g., the nominal power value is 500 W and the reflected power is 100 W, the generator has to deliver 600 W.

For the regulation with respect to power U_{DC} or RF_{PEAK} may be chosen as a limit. The limit has to be set, e.g., to a voltage that must not be exceeded in the process.

Regulation with respect to voltage

DC BIAS regulation

The DC BIAS regulation regulates the DC-BIAS voltage U_{DC} (process voltage), which is created across the plasma.

Notice!

Please notice that certain processes create a DC BIAS voltage which is very low or even too low to be measurable! In these cases, it is not sensible to select the DC BIAS regulation.

RF PEAK regulation

The RF-PEAK regulation regulates the RF peak voltage RF_{PEAK}, which is created across the plasma.

P_I or ΔP can be chosen as a limit when regulating with respect to voltage.

EXAMPLE "POWER REGULATION"

This example shows the switch-on process when regulating with respect to a power (regulation modes POWER or DELTA-P).

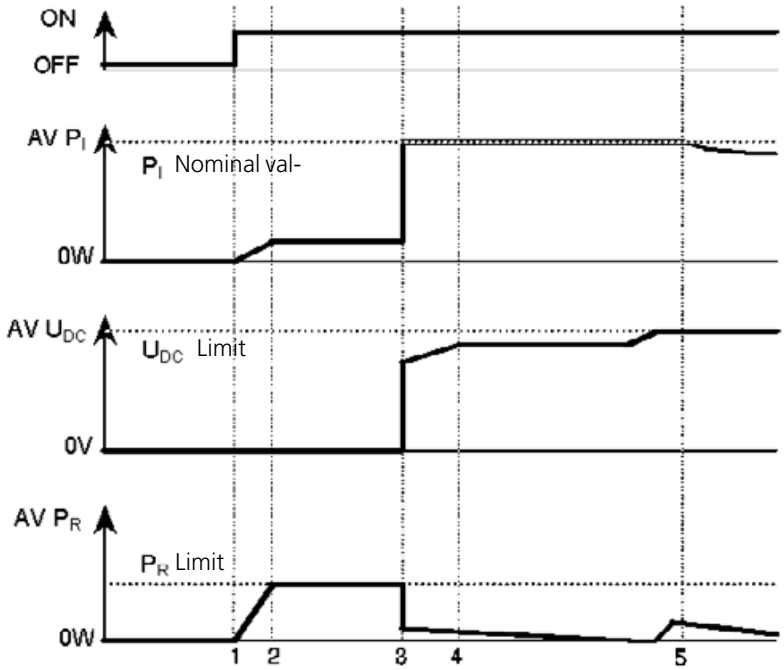


Fig. 3.4 Signal curve under power control

Time 1

- The power operation is switched on (ON).
- The power increases in a linear manner.
- It is assumed that the plasma is not ignited immediately, and thus the RF system is not matched: The reflected power PR thus increases rapidly.

Time 2

- The reflected power PR reaches the preset limit and curbs the forward power.
- The regulation now keeps each of the powers P_I and P_R constant until the plasma is ignited.

Time 3

- The plasma is ignited and a DC BIAS voltage is present.
- PR goes almost to zero and the preset nominal power value is attained.

Time 4

- The DC BIAS voltage usually increases slightly.
- The reflected power PR decreases due to an improved match by the matching network.

Time 5

- The DC BIAS voltage reaches its limit.
- The regulation now keeps the DC BIAS voltage constant at the set value.
- In case that the DC BIAS voltage falls below the preset limit again, the power regulator takes over regulation again.

EXAMPLE "VOLTAGE REGULATION"

This example illustrates the switch-on sequence when regulating with respect to voltage (regulation modes DC BIAS or RF PEAK).

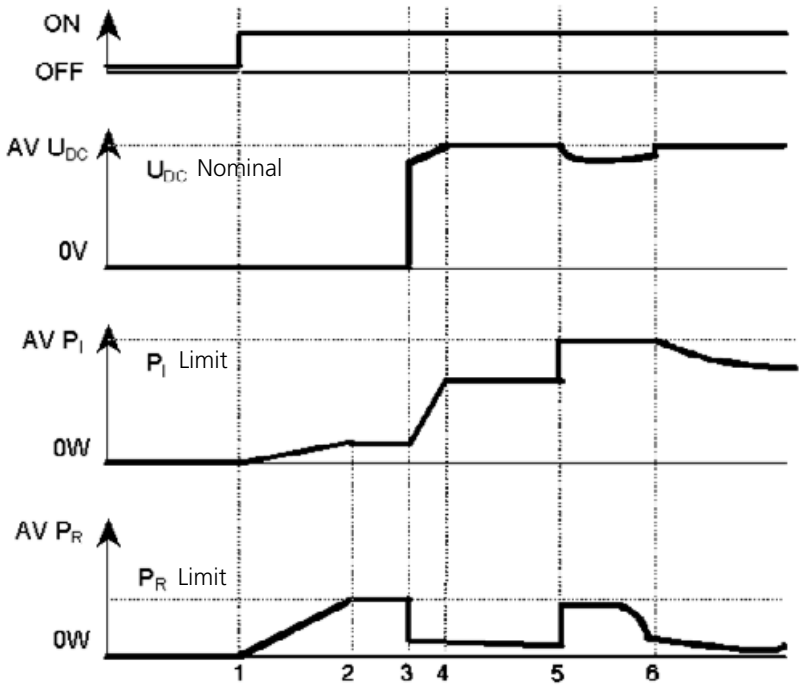


Fig. 3.5 Signal curve under voltage control

Time 1

- The power operation is switched on.
- Forward and reflective powers increase in a linear manner until the limit P_R is reached.

Time 2

- The reflected power P_R reaches its limit and thus limits P_I.

Time 3

- The plasma is ignited, P_I continues to increase.

Time 4

- The DC BIAS voltage has reached its nominal value.
- In the case that the DC BIAS voltage already increases above its nominal value due to the plasma ignition, P_I will not continue to increase. Rather, it will decrease to an appropriate power value immediately after Time 3.

Time 5

- Fault in the sputtering system: The DC-BIAS voltage decreases.
- P_I increases immediately (at most up to the limit P_I).
- However, in the example shown, the increased power is not sufficient to regulate the voltage to the nominal value again. Only at Time 6, the voltage regulation reverts back to its default state.

3.6 TECHNICAL DATA

Detailed information can be found in the documents.

- Technical specifications
- Cooling water specification

4 VARIANTS, ACCESSORIES

Chapter Outline:

Who is this chapter directed at?

This chapter is intended for all persons who install and operate special variants of the basic model of the RF Generator PFG-RF or accessories for them.

Chapter contents

The chapter contains information about the functionality and technology of model variants and accessories of the RF Generator PFG-RF, their use, fields of application, and technical data.

4.1 MODEL VARIATIONS

Different output powers

The generators can be supplied with the following output powers:

- 300 W
- 600 W
- 1000 W
- 1600 W
- 2500 W
- 5000 W

Identical functions

These generators only differ in the dimensioning of the power units as well as the dimensions for installation.

Functions, construction and operation of the generators are identical.

4.2 ACCESSORIES AND OPTIONS

ACCESSORIES

The following accessories are required for the generators:

Necessary accessories

- PFM series matchbox
- coaxial cable

OPTIONS

The generators are available with the following options:

- Master oscillator with phase shifter

  The master oscillator with phase shifter permits the simultaneous RF operation of several generators.

- RF selector switch

  The RF selector switch permits the use of a single generator for various process stations.

- RS 232 / RS 485 interface

  The PFG 300 … 5000 RF generators contain both interfaces.

- Profibus data interface

  The PFG 300 RF … PFG 5000 RF generators can also be fitted with a PROFIBUS interface instead of the RS232 and RS485 serial interfaces.

- RF INHIBIT INPUT (keying input)

  PFG 1600 … PFG 5000 are by default equipped with an RF inhibit input at the A/D interface.
  PFG 600 and PFG 1000 are optionally equipped with an RF inhibit input via a SUB MINUX socket.
  For the PFG 1000, the RF inhibit input is optionally wired via the A/D interface.

5 INSTALLATION

Chapter Outline:

Who is this chapter directed at?

This chapter is intended for all persons who install RF Generator PFG-RF on the basis of this operating manual.

Chapter contents

The chapter contains advice regarding the correct mechanical and electrical installation of the RF Generator PFG-RF.

5.1 TRANSPORT, STORAGE

GENERAL NOTICES

After receiving the generator:

- *Check the generator immediately upon delivery for completeness in accordance with the delivery note and also for visible damages incurred during transport.*
- *In order to retain the right of recourse, report any damages incurred during transport immediately in writing to the forwarding agent, the insurance company and HÜTTINGER.*
- *The device should always be protected against physical impact. Always transport it in its original packaging.*

Orientation during transport and storage

Warning!

RF Generator PFG-RF may only be transported and stored in a horizontal position (see fig. 5.1).
If transported and stored in a different position, components may fall from their receptacles and cause damage.

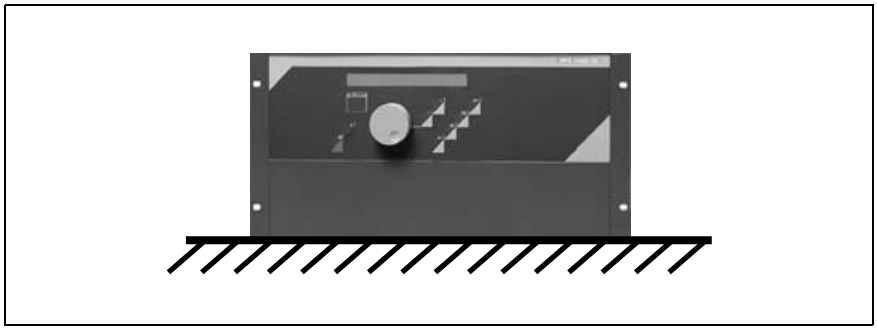


Fig. 5.1 Orientation during transport and storage

Storage conditions

If you do not install the generator immediately after delivery, store it in its original packaging under environmental conditions specified in the 'Technical Specifications' document.

5.2 UNPACKING

Carefully unpack the generator.

Remove the plastic cover.

PACKAGING MATERIAL

Disposal

If the packaging will not be kept for possible transport at a later time, it should be disposed of properly. The following materials are used for packaging and for the protection of the equipment:

- Corrugated cardboard
- Neopolen 1710
- Ethafoam 400

All packaging materials must be disposed of according to the relevant regulations of the delivery area.

5.3 INSTALLATION AND ASSEMBLY

The generator is designed as a 19'' rack module (PFG 300 RF: ½ 19" rack module).

Warning!

During the installation of the generator into a cabinet, the air vents on the side must be kept free from obstruction. There must be sufficient distance to the rear cabinet wall to permit the heated air to escape through the rear air vents.

The incoming air temperature must not be above 35 °C.

- *Ensure that the air vents remain free of obstruction.*
- *Keep a distance of 10 cm to the rear cabinet wall.*

When installing several generators in one switching cabinet:

- *Ensure (if necessary through additional ventilation measures) that each generator has an unobstructed air flow with an incoming air temperature of no more than 35 °C.*
- *Prevent heated air from being sucked in again.*

5.4 CONNECTION

SAFETY

Life Threatening Voltage!

The generators are connected to 230 V, 3x208 V or 3x400 V. Improper installation of the generators can be life-threatening due to electrical voltages!

Qualified personnel

The electrical connection of the generators must only be carried out by personnel who are qualified and trained for work with electrical equipment. These personnel must be accustomed with and abide by the relevant safety regulations of the installation area for the erection of electrical equipment.

Observe the safety information in chapter 2: "Safety".

Connecting the safety and control circuits

Integrating into a system controller

The following interfaces are used for integrating into a system controller:

- A/D interface (X1)
- RS 232 C interface (X3)
- RS 485 interface (X6)
- Fiber optic cable (U1, U2)
- Profibus interface (optional)

The interfaces are located at the rear side of the device. As required, one or more interfaces can be wired.

Warning!

The plugs and cables connected to the interface must be shielded. Connect the shielding to the housing.

Notice!

Detailed information on interface assignments and on integrating the generator into a process-computer-controlled environment is provided in chapter 8: "Interfaces".

A/D interface (X1)

The A/D interface is a 37-pin SUB D socket.

If you want to connect the A/D interface:

↳ *Connect the signals which you will use to the interface.*

RS 232 C interface (X3)

The RS 232 interface is a 9-pin SUB D socket.

If you want to connect the RS 232 interface:

↳ *Connect the interface (see chapter 8.7: "RS 232 C (X3)")*

RS 485 interface (X6)

The RS 485 interface is a 15-pin SUB D socket.

If you want to connect the RS 485 interface:

↳ *Connect the interface (see chapter 8.8: "RS 485 (X6)")*

Fiber optic cable (U1, U2)

The fiber optic interfaces are used for the connection to the fiber optic ring.

To connect the generator to the fiber optic ring:

↳ *Connect the fiber optic cables.*

Connecting the interlocks

The next step is to connect the interlocks. The interlocks are connected to pin 8 and pin 26 of the A/D interface (X1).

More detailed information about the interlocks can be found in chapter 2.5: "Safety devices".

Warning!

Interlock1 is to be wired with potential-free contacts. No external voltages may be connected.

If you do not want to wire Interlock1:

- *Use the supplied 37-pin plug. Pins 8 and 26 of this plug are bridged by the factory.*

If you would like to wire Interlock1:

- *Remove the bridge between pin 8 and pin 26 from the plug supplied with the A/D interface (X1).*
- *Connect one or more safety switch(es) (break contact) potential-free in series between pin 8 and pin 26.*

Wiring the RF reference input

The RF input interface (X5) is an RF reference input. When operating a generator, the RF reference input is fed by the generator itself (individual operation). If several generators are to be operated synchronously (synchronous operation), an external master oscillator (common exciter) must be connected here.

Individual operation

During individual operation, the RF input (X5) is fed directly from the generator; the RF input (X5) must be connected to the RF output (X4). When the generator is shipped, the two interfaces are already connected to each other.

- *Connect the RF input (X5) to the RF output (X4) via a short BNC cable.*

Synchronous operation

In synchronous operation, the RF input (X5) is fed by a master oscillator.

- *Connect the master oscillator to the RF input (X5) via a short BNC cable.*
- *Install a terminating resistor of 50 W at the RF output (X4).*

MAKING THE ELECTRICAL CONNECTIONS

RF power output (P_{out})

The RF power output (P_{out}) is designed as follows:

- Coaxial socket "N" (PFG 300 RF … PFG 1000 RF)
- Coaxial socket "7/16" (PFG 1600 RF … PFG 5000 RF)

Connect the generator to the matchbox via the coaxial cable.

Emergency-power-off switch

If you connect an emergency-power-off switch:

Install the emergency-power-off switch so that on actuation, the generator is completely separated from mains.

Connecting the power supply unit

The mains connection is made at the rear side of the device.

Life Threatening Voltage!

Before connecting to mains, ensure that the separation device in the external unit is open and protected against switching on again.

PFG 300 RF

The mains supply is connected to the RF generators of type PFG 300 RF using the supplied mains cable.

PFG 600 RF … PFG 5000 RF

The mains connection of RF generators of type PFG 600 RF … PFG 5000 RF is made for three phases using a strip terminal.

Connect the individual wires to the strip terminal.

Checking electrical connections

After all electrical connections have been made:

Check all plugs and cables for secure seating.

The generator is now ready to be switched on.

5.5 DISMANTLING, PACKAGING

Dismantling

To dismantle the generator:

- *Disconnect the generator from mains.*
- *Disconnect all remaining electrical connections in reverse order of that described in chapter 5.4: "Connection".*

Packaging

To pack the generator:

- *If possible, use original packaging.*

5.6 DISPOSAL

Disposal

The used power semiconductors and power resistors contain beryllium oxide and must thus be disposed of as hazardous waste.

The remaining components of the generators can be disposed of as electronic waste.

- *Waste must be disposed of in accordance with the relevant waste disposal regulations.*

6 OPERATION, CONTROL

Chapter Outline:

Who is this chapter directed at?

This chapter is intended for all persons who operate RF Generator PFG-RF on the basis of this operating manual.

Chapter contents

The chapter contains a description of the modes and states of operation as well as operating instructions for RF Generator PFG-RF.

6.1 COMMISSIONING

The generators do not need a special commissioning procedure. They can be switched on immediately after installation.

6.2 GENERAL CONTROL

CONTROL ELEMENTS

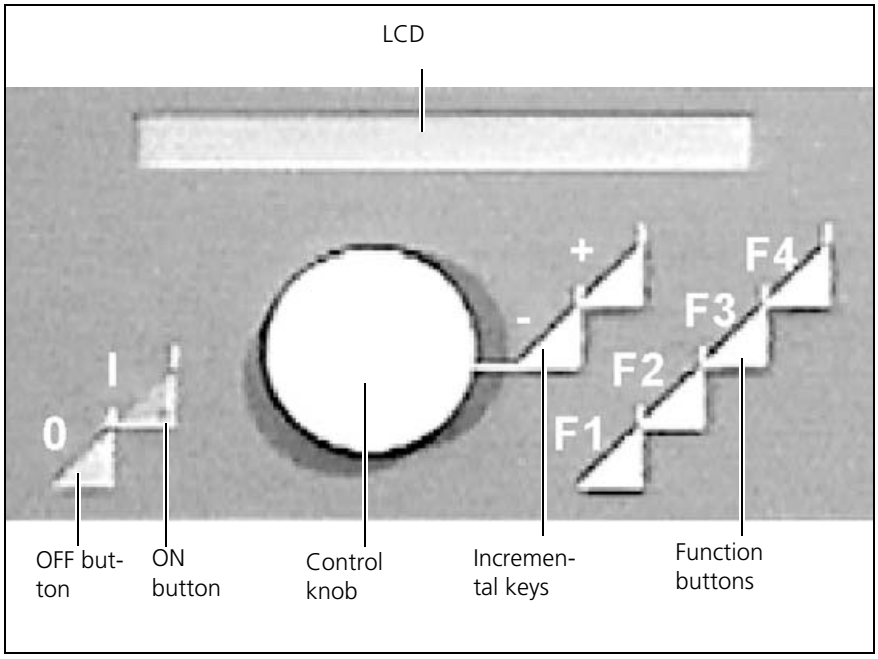


Fig. 6.1 Operation and display elements

The power operation is switched on by pressing the green ON button **(I)**. By pressing the red OFF button **(O)**, the power operation is switched off.

The rotary button permits the modification of numeric values (e.g., "52").

Rotating the button clockwise increases the value, rotating the button anti-clockwise decreases the value in large steps.

By briefly pressing the two incremental keys, the adjustable values can be increased (incremental key +) or decreased (decremental key -). In general, a more precise setting of numerical values can be achieved by using the incremental keys instead of the rotary button.

If the incremental keys are held pressed down, the speed with which the values change increases.

The function keys are used to move between and within the menus, as well as to select parameters.

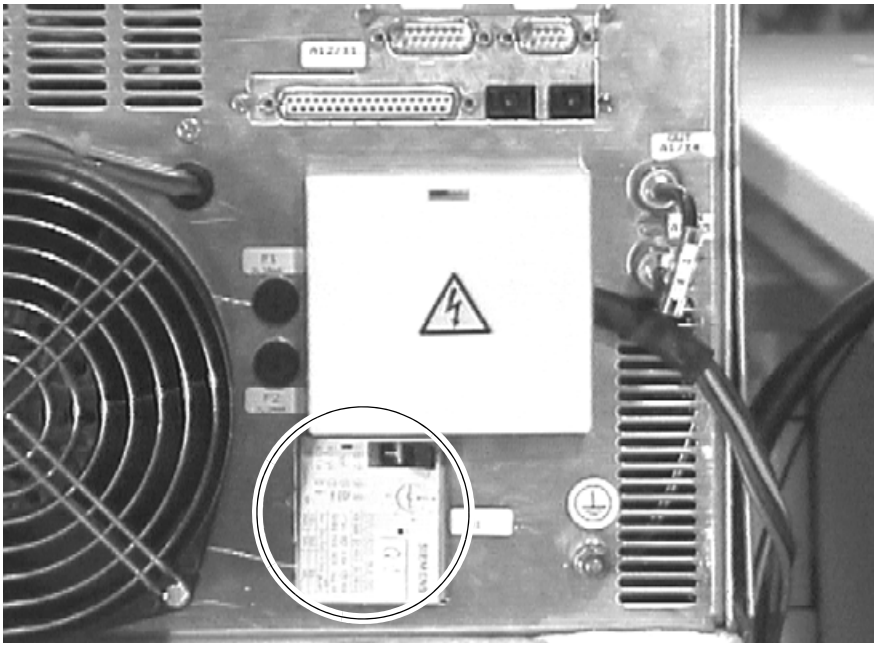


Fig. 6.2 Main switch

The main switch (Q1) is located on the back; it switches the generator on.

Display Elements

The illuminated, two-line LCD display is used for the display of the actual values, set values and error messages. They are displayed in the form of menus. Values that may be edited are preceded by a star (*).

PROTECTION SWITCHES, FUSES

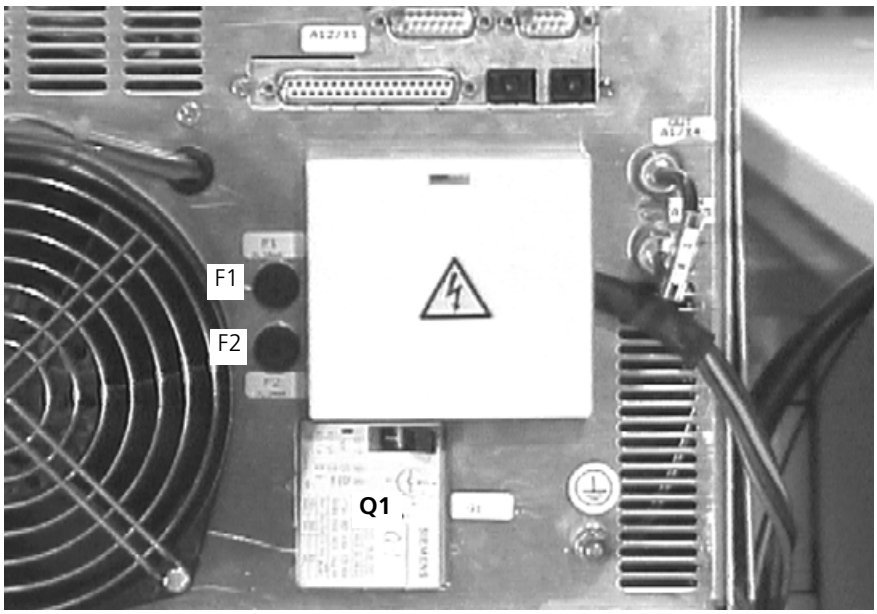


Fig. 6.3 Protection switches and fuses

The protection switches and fuses are located at the rear side.

The main switch **(Q1)** is designed as circuit breaker. The fuses **(F1** and **F2)** are thermal fuses.

The PFG 300 RF only features thermal fuses **(F1** and **F2)**.

FUNCTION KEYS

Depending on the type of operation, the function keys are assigned differently. The individual assignments are explained in detail in the following.

The respective current assignment of the function keys is shown on the LCD display.

The display above shows that the current assignment of the function key F1 is NEXT and that of the function key F2 is CHANGE. Also, the nominal value for the direct power PI has a star: It can be changed using the rotary button or the incremental keys.

F1: NEXT — With F1: NEXT, you move from one main menu to the next.

F1: EXIT — With F1: EXIT, you move from one submenu back to the associated main menu. In case you have unintentionally changed a value and have not yet pressed F2: ENTER, you can exit the submenu with F1: EXIT without saving the change.

F2: CHANGE — With F2: CHANGE, you move from a main menu into the associated submenu. In the main menus, the generator settings are displayed, the submenus let you can change the settings with this function key.

F2: ENTER — With F2: ENTER, you confirm the values set in the submenus and move to the next submenu.

F3 — With F3, you change between the generator menus and the matchbox menus. In case you have changed a value and have not yet pressed F2: ENTER, you can exit the respective menu with F3 without saving the change.

F4: RESET — With F4: RESET, you acknowledge error messages.

CONTROL PROGRAM

Control program

The generator is controlled by an internal program, the control program. The control program is permanently stored in an EPROM memory module.

Settings are retained

Following the self-test, the generator takes over all settings that were in use when the device was last switched off.

With the generator switched on, settings can be changed using the control panel or via the interfaces. When the generator is switched off, the current settings are stored in a battery-buffered RAM.

6.3 RECOGNITION OF OPERATIONAL STATES

The operating state is indicated by the lighting up of the green ON button on the control panel.

Operating state ON

The generator is in power operation, if the green ON button is lit.

Operating state OFF

The generator is not in power operation, if the green ON button is **not** lit.

6.4 SWITCHING THE GENERATOR ON AND OFF

The generator is switched on via the main switch (Q1) at the rear. Depending on the operation mode, power operation is switched on and off using the control elements on the front panel or via an interface:

- In the operation modes REALTIME and LOCAL, the power operation is switched on via the green ON button and switched off via the red OFF button.
- In the operation modes REMOTE1, REMOTE2, REMOTE3, REMOTE4, RS 232, RS 485 and PROFIBUS, the power operation is switched on and off via the interfaces.

Warning!

After the generator has been switched on, the settings which were set prior to the last time the generator was switched off are taken over.

Switching on mains

Switch on the main switch (Q1).

After switch-on, the built-in microprocessor is initialized (lasting approx. 2 seconds). During this time, the installed software version of the generator is displayed.

Switching on the power operation

The power operation can now be switched on.

Press the ON key or apply +24 V to pin 25 (X1).

The ON button will light up. The generator now creates an output power according to the settings which were current when the device was last switched off.

Switching off power operation

Press the OFF key or apply +0 V to pin 25 (X1).

Power operation is now switched off.

Switching off mains

Switch off the main switch (Q1).

The generator is switched off.

6.5 SETTING GENERATOR AND OPERATION MODES

The generators can be operated in various modes. This allows the generator to be operated in different ways. For example, the generator can be controlled either via the control panel or via remote control.

An overview of the operation modes and the way in which the settings are made can be found in the following table.

Operation modes		
	Operation mode	**Setting through**
Internal	REALTIME	Control panel
	LOCAL	Control panel
External mode	REMOTE1	Analog/digital interface
	REMOTE2	A/D interface / control panel
	REMOTE3	Analog/digital interface
	REMOTE4	A/D interface (TIS emulation)
	RS 232	RS 232 C interface
	RS 485	RS 485 interface
	PROFIBUS	External profibus interface
The generator is operated in the operation modes REALTIME and LOCAL through the control panel, and in other operation modes via the interfaces.		

Tab. 6.1 Operation modes

The different operation modes are described in the following sections.

In the following, the menus of the internal and external operation modes are explained. The overview figure at the top of each page illustrates the arrangement of the current (shaded) menu group in the menu structure, the arrows indicate the direction of movement within the menu.

The functions that can be selected in the individual menus and their parameter settings are described in chapter 3.3: "Technology".

Operation mode: REALTIME

The operation mode REALTIME is an **internal** operation mode. It is suitable for locally controlled processes. The operating personnel can intervene directly in the process during operation and thus react immediately to various process conditions.

In this operation mode, the generator is operated by use of the control panel. All generator values and settings (output power, limits etc.) can be viewed and edited both in the display menu and in the submenus intended for this purpose.

Operation mode LOCAL

The operation mode LOCAL is an **internal** operation mode. It is designed for processes that are not connected to external control systems, but rather are to be controlled directly from the generator.

In this operation mode, the generator is operated by use of the control panel. The settings of the generator are made via the operating panel in the submenus intended for it. This prevents accidental changes to the settings during the process.

Operation mode REMOTE1

The operation mode REMOTE1 is an **external** operation mode. It is designed for processes that are controlled by an external control system.

In this operation mode, the entire generator is controlled externally via the A/D interface (X1). The operating personnel do not have access to the process from the control panel. The Matchbox remains operable through the generator provided it is connected via the fiber optic cable.

Operation mode REMOTE2

The operation mode REMOTE2 is an **external** operation mode. It is designed for processes that are controlled by an external control system.

In this operation mode, the output power can **only** be switched on and off via the A/D interface (X1). Apart from this, the generator is operated and configured via the control panel (see REALTIME).

Operation mode REMOTE3

The operation mode REMOTE3 is an **external** operation mode. It is designed for processes that are controlled by an external control system.

In this operation mode, the entire generator is controlled externally via the A/D interface (X1). The operating personnel do not have access to the process from the control panel. The Matchbox remains operable through the generator provided it is connected via the fiber optic cable.

In contrast to REMOTE1, an additional analog nominal value (voltage) can be supplied from the outside.

Operation mode REMOTE4

The operation mode REMOTE4 is an **external** operation mode. It is designed for processes that are controlled by an external control system. Its purpose is to emulate the devices of the older TIS series. Ensure that regulation = POWER and limits = DCBIAS is set before switching.

In this operation mode, the entire generator is controlled externally via the A/D interface (X1). Via the control panel, the operation personnel can adjust the quantity that is currently not being regulated towards. The Matchbox remains operable through the generator provided it is connected via the fiber optic cable.

Operation mode RS 232

The RS 232 operation mode is an **external** operation mode. It is designed for processes that are controlled by an external control system. The operating personnel do not have access to the process from the control panel.

In this operation mode, the generator is controlled via the RS 232 C interface. The internal generator settings are taken over when the operation mode is changed to RS 232; settings can be changed via the RS 232 C interface during operation.

In the operation mode RS 232, all control and measurement signals of the generator and the Matchbox can be transferred via the RS 232 C interface. Refer to chapter 8: "Interfaces".

Operation mode RS 485

The operation mode RS 485 is an **external** operation mode. It is designed for processes that are controlled by an external control system. The operating personnel do not have access to the process from the control panel.

In this operation mode, the generator is controlled via the RS 485 interface. The internal generator settings are taken over when the operating mode is changed to RS 485; settings can be changed via the RS 485 interface during operation.

In the operation mode RS 485, all control and measurement signals of the generator and the Matchbox can be transferred via the RS 485 C interface. Refer to chapter 8: "Interfaces".

Operation mode PROFIBUS

The operation mode PROFIBUS is an **external** operation mode. It is designed for processes that are controlled by an external control system. The operating personnel do not have access to the process from the control panel.

The generator is designed as a DP-slave.

In the operation mode RS PROFIBUS, all important control and measurement signals of the generator and the Matchbox can be transferred via the interface. Refer to chapter 8: "Interfaces".

Matchbox mode AUTOMATIC

As soon as the matchbox recognizes from the development of a DC-BIAS voltage that the plasma has ignited or as soon as it measures an RF-PEAK voltage, the capacitors are automatically adjusted to reach an optimum. The position of the capacitors is assumed to be optimal if the reflected power is equal to zero or at a minimum.

Matchbox mode DCAUTO

As soon as the matchbox recognizes from the development of a DC-BIAS voltage that the plasma has ignited, the capacitors are automatically adjusted to reach an optimum. The position of the capacitors is assumed to be optimal if the reflected power is equal to zero or at a minimum.

MATCHBOX MODE MANUAL

The capacitors move to the manually set nominal position. Positions between 0 and 1000 (corresponding to the minimum and maximum setting of the capacitors) may be set in steps of 1 ‰ .

MATCHBOX MODE REMOTE

Using the remote function, the operation mode of the matchbox can be switched to external. In this case, the generator only has read access. All other functions are supplied to the matchbox via its external SUB-D connection.

MATCHBOX MODE FREEZE

With this mode, the variable capacitors of the matchbox can be immediately stopped ("frozen") in their current position.

INTERNAL OPERATION MODES

The following image shows the menu structure of the internal operation modes.

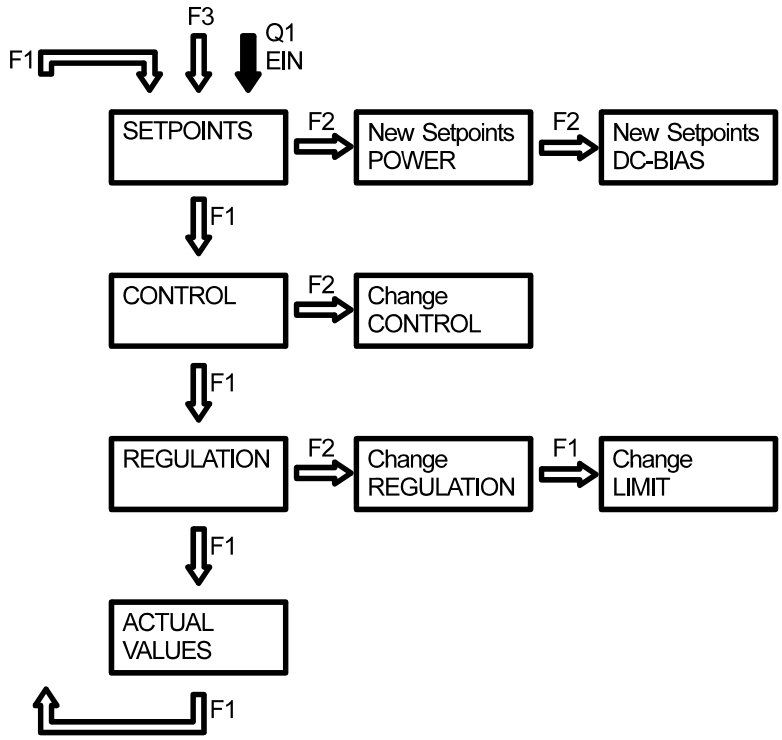
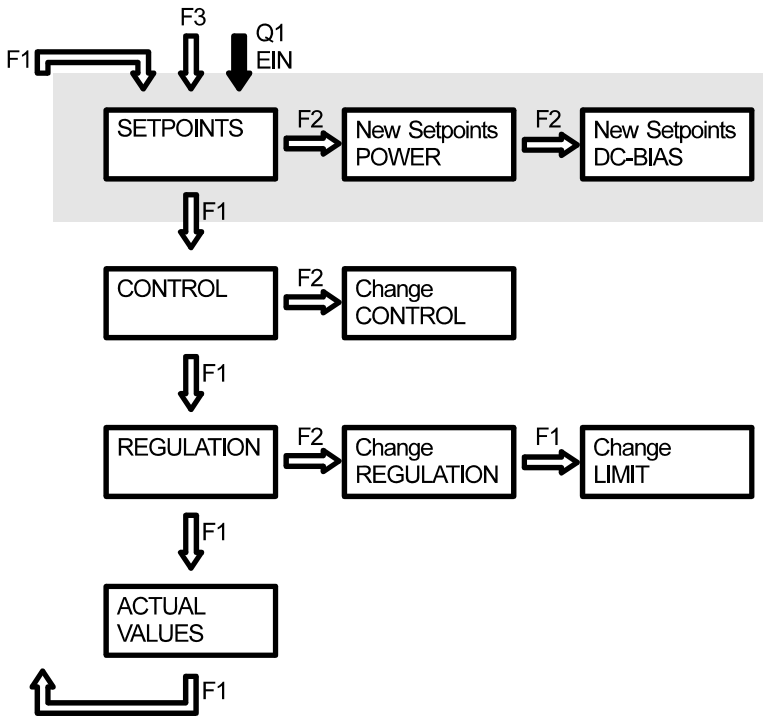


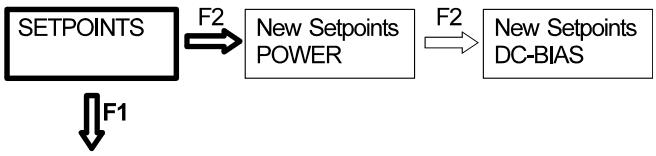
Fig. 6.4 Menu structure: internal operation modes

INTERNAL: SETPOINTS

In this menu, you can set the nominal values (SETPOINTS).



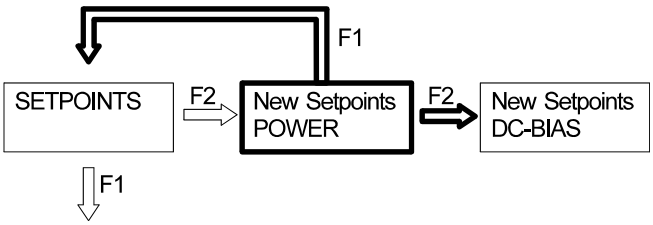
SETPOINTS



Setpoints:		*Power	5.00 kW
F1: NEXT	F2: CHANGE	DC-Bias	2040V

In this menu, the nominal values (SETPOINTS) are displayed. Depending on the type of regulation and limit that have been set, either the DC-BIAS voltage or the RF-PEAK voltage is shown.

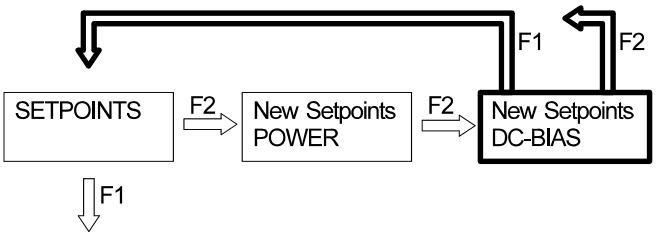
NEW SETPOINTS POWER



New Setpoints:		*Power	5.00 kW
F1: EXIT	F2: ENTER	DC-Bias	2040V

In this menu, you can edit the setpoint for the direct power P_I (POWER).

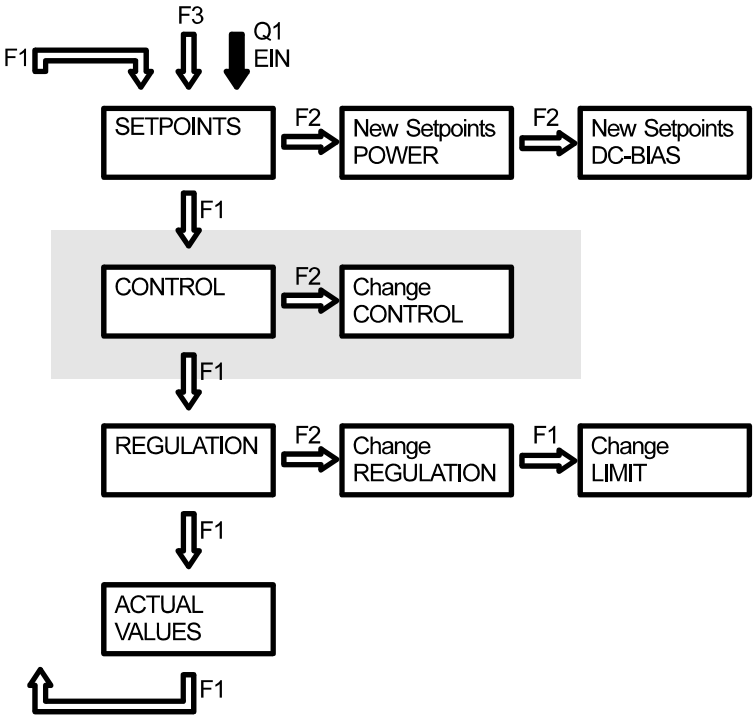
NEW SETPOINTS DC-BIAS



New Setpoints:		*Power	5.00 kW
F1: EXIT	F2: ENTER	DC-Bias	2040V

In this menu, you can edit the setpoint for the DC-BIAS voltage U_{DC} (DC-BIAS). If the fiber optic bus is not connected, the setting must be specified as 0 … 100.0 %.

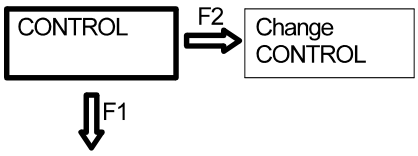
INTERNAL: CONTROL



The operation modes (CONTROL) are described at the start of this chapter. You can set the following operation modes:

- REALTIME
- LOCAL
- REMOTE1
- REMOTE2
- REMOTE3
- REMOTE4
- RS 232
- RS 485
- PROFIBUS (optional instead of RS232 / RS485)

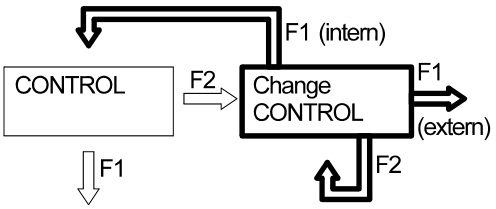
CONTROL



CONTROL	REALTIME
F1: NEXT	F2: CHANGE

In this menu, the operation mode (CONTROL) is displayed.

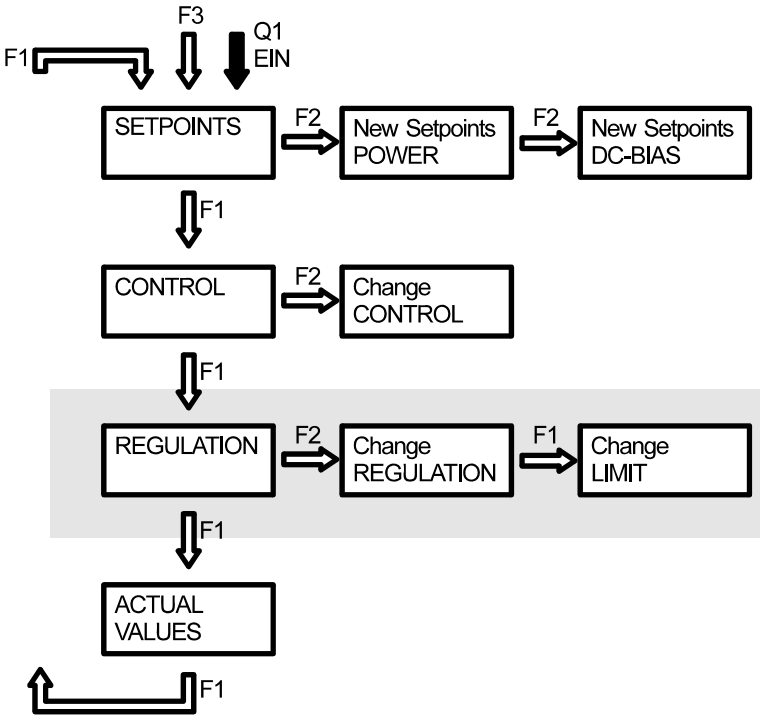
CHANGE CONTROL



CONTROL:	LOCAL"
F1: EXIT	F2: ENTER

In this menu, the operation mode (CONTROL) can be changed.

INTERNAL: REGULATION



In this menu, you can change the regulation mode (REGULATION) and the limit mode (LIMIT).

REGULATION

REGULATION: POWER	LIMIT: DC-BIAS
F1: NEXT	F2: CHANGE

This menu displays the regulation mode (REGULATION) and the limit mode (LIMIT).

CHANGE REGULATION

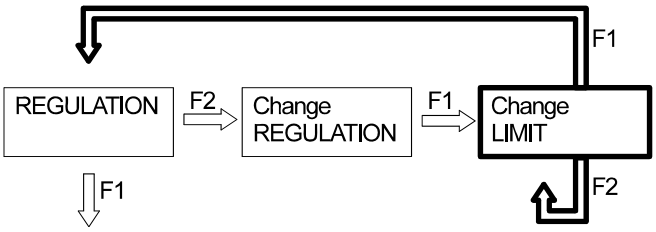
*REGULATION: POWER	LIMIT: DC-BIAS
F1: EXIT	F2: ENTER

In this menu, the regulation mode (REGULATION) can be changed.

Notice!

Depending on the setpoint specified, one of the internal regulators may intervene if the regulation mode is changed during operation, and limit the output power. In this case, the setpoint that is not required and that acts as limit must be increased.

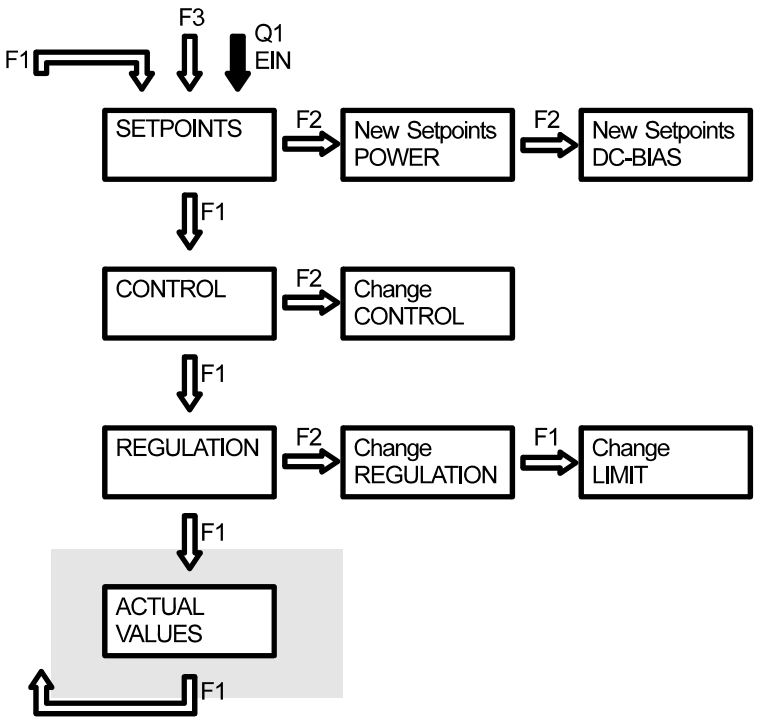
CHANGE LIMIT



REGULATION: POWER	*LIMIT: DC-BIAS"
F1: EXIT	F2: ENTER

In this menu, the limit mode (LIMIT) can be changed.

INTERNAL: ACTUAL VALUES



ACTUAL VALUES

*FWDP:	5.00 kW	DC-BIAS" 136 V	CT: 322
REFP:	0.00 kW		CL: 621

This menu displays the current values (ACTUAL VALUES). The value that has a star (*) attached is the reference input for the regulation.

FWDP stands for direct power P_I, REFP stands for reflected power P_R.

External operation modes

The following images show the menu structure of the external operation modes.

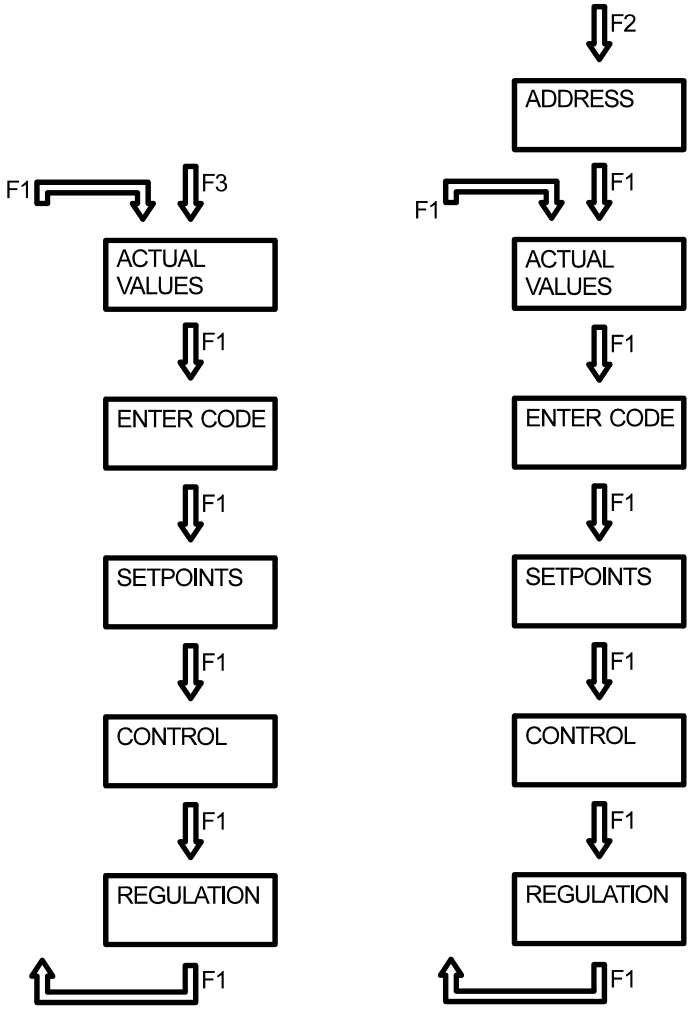
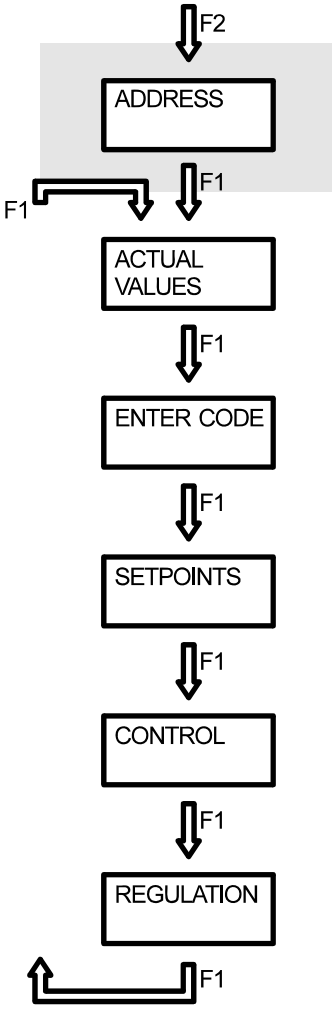


Fig. 6.5 Menu structures: external operation modes

The left image shows the general menu structure (REMOTE, RS 232). The right image shows the menu structure of the operation modes RS485 and PROFIBUS. The difference is the additional menu ADDRESS.

EXTERNAL: ADDRESS

This menu appears only if one switches to the operation modes RS 485 and PROFIBUS.



RS 485 ADDRESS

```
ADDRESS FOR RS 485:                    2
F1: EXIT                    F2: ENTER
```

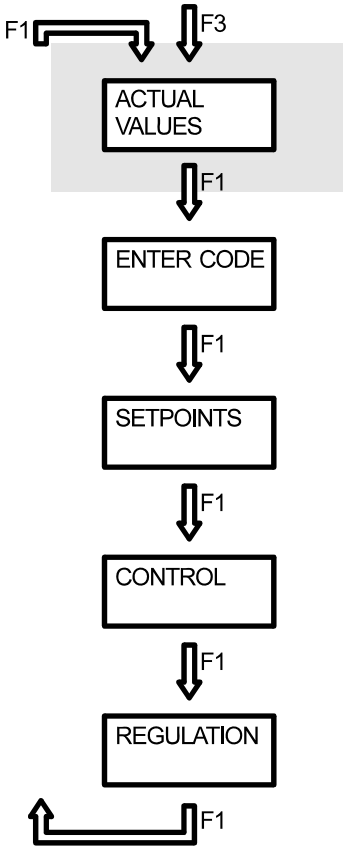
With this menu, you can set the address of the generator on the RS 485 bus.

PROFIBUS ADDRESS

ADDRESS FOR PROFIBUS: :	32
F1: EXIT	F2: ENTER

With this menu, you can set the address of the generator on the PROFIBUS.

EXTERNAL: ACTUAL VALUES



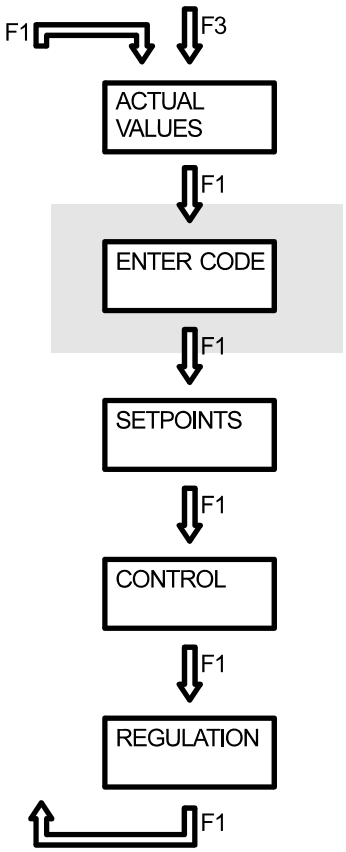
ACTUAL VALUES

*FWDP:	5.00 kW	DC-BIAS" 136 V	CT: 322
REFP:	0.00 kW		CL: 621

This menu displays the current values (ACTUAL VALUES). The value that has a star (*) attached is the reference input for the regulation.

FWDP stands for direct power P_I, REFP stands for reflected power P_R.

EXTERNAL: ENTER CODE

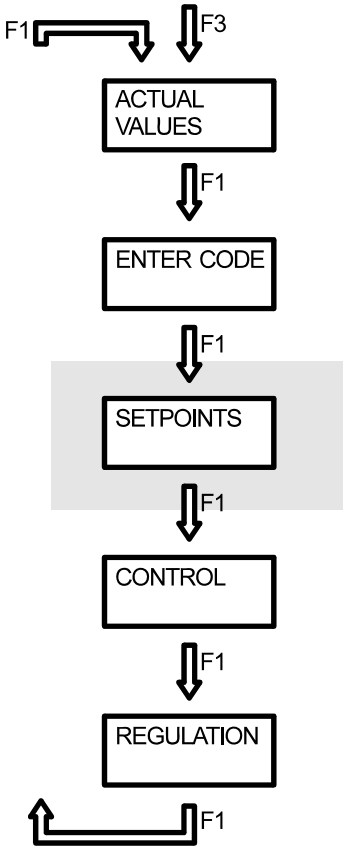


ENTER CODE

PLEASE ENTER CODE:	0
F1: EXIT	F2: ENTER

From this menu, you can return from an external operating mode back to the LOCAL operating mode. For this, you must enter a code. The code for returning to the LOCAL operation mode is 727. If a wrong code is entered, then the generator remains in the respective external operation mode and the menu ENTER CODE remains on display.

EXTERNAL: SETPOINTS

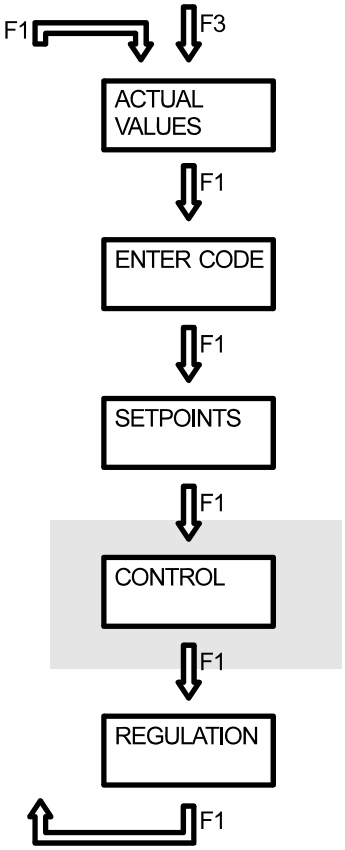


SETPOINTS

Setpoints:	Power	5.00 kW
F1: NEXT	DC-Bias	2040V

This menu displays the nominal values (SETPOINTS).

EXTERNAL: CONTROL

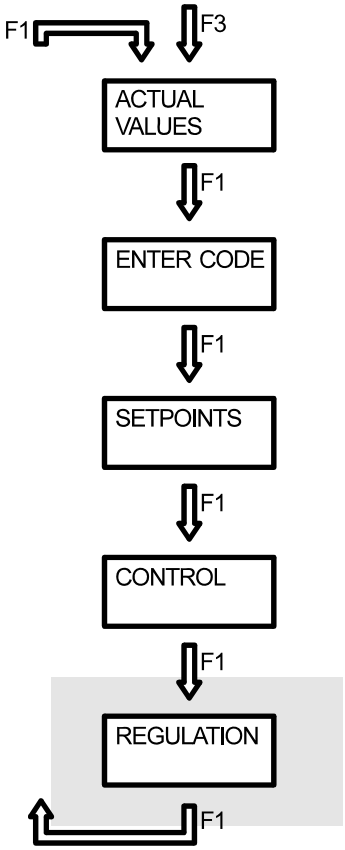


CONTROL

CONTROL:	"RS485"	Address: 2
F1: NEXT		

In this menu, the operation mode (CONTROL) is displayed. If the generator is in operation mode RS485 or PROFIBUS, the address that it is set to on the bus is also displayed.

EXTERNAL: REGULATION



REGULATION

```
REGULATION: POWER          LIMIT: DC-BIAS"
F1: NEXT
```

This menu displays the regulation mode (REGULATION) and the limit mode (LIMIT).

MACHTBOX MENU

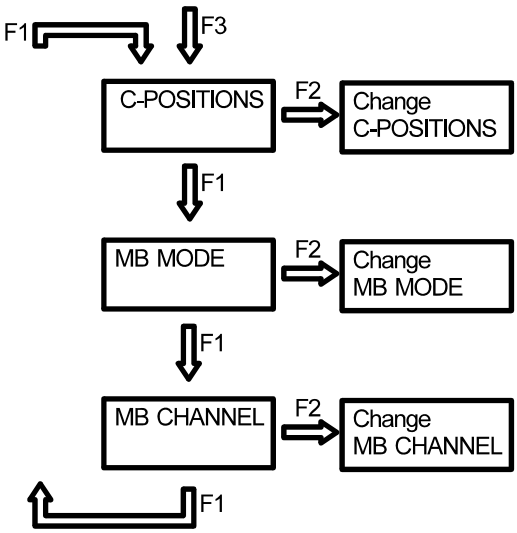


Fig. 6.6 Menu structure: Matchbox menu

In the matchbox menu, current values and settings of the matchboxes can be displayed and edited.

With F3, you can switch between the menus of the internal (or external) operating modes and the matchbox menu:

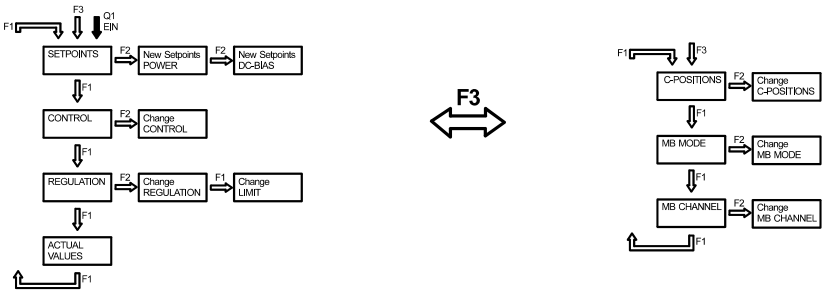
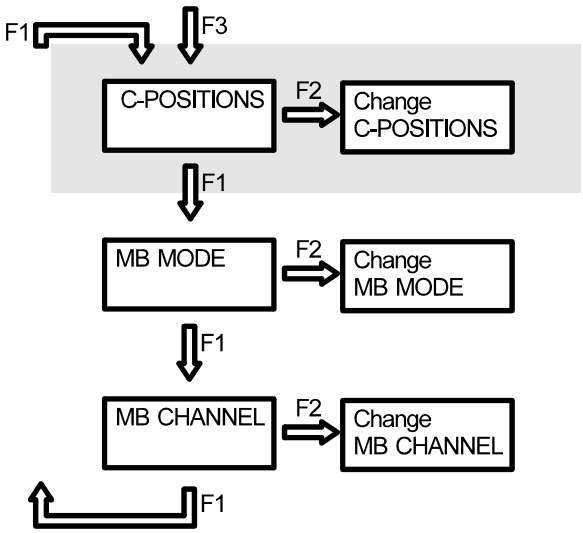
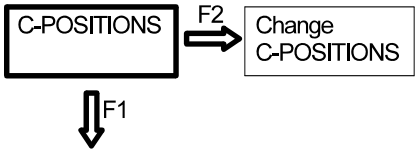


Fig. 6.7 Switching to the matchbox menu

MATCHBOX MENU: C-POSITIONS



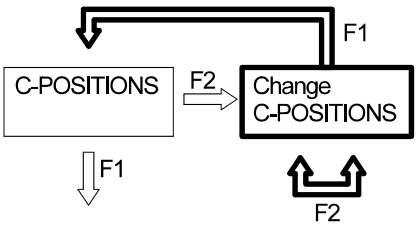
C-POSITIONS




```
MATCHBOX:                          C-TUNE: 500
F1: NEXT                F2: CHANGE C-LOAD: 500
```

This menu displays the matchbox mode and the target positions of the capacitors.

CHANGE C-POSITIONS

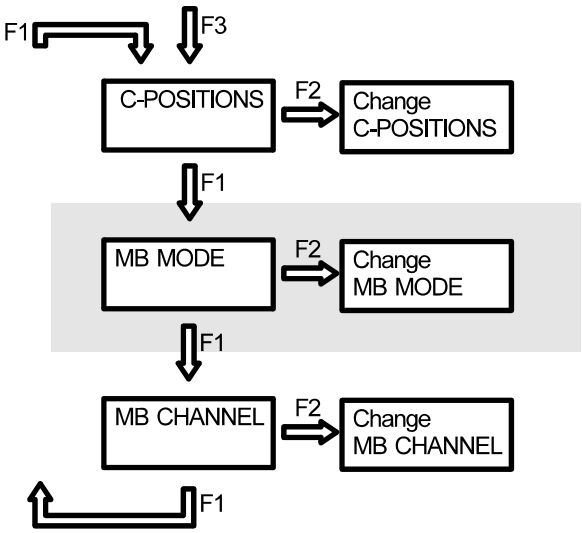



```
REFP:       0 W                    *C-TUNE500
F1: EXIT                F2: NEXT   C-LOAD: 500
```

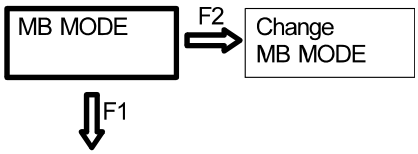
In this menu, you can edit the target positions of the capacitors. To do this, the reflected power PR (REFP) is displayed, which permits easy setting of the minimum reflected power PR in the MANUAL matchbox mode.

Use F2: CHANGE to switch between the two capacitors.

MATCHBOX MENU: MB MODE



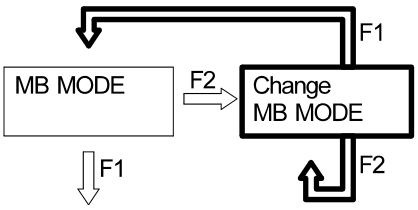
MB MODE




```
MATCHBOX MODE: AUTOMATIC:
F1: NEXT                    F2: CHANGE
```

This menu displays the matchbox mode (MATCHBOX MODE).

CHANGE MB MODE




```
MATCHBOX MODE: AUTOMATIC:
F1: EXIT                    F2: ENTER
```

In this menu, you can set the matchbox mode.

The following modes are available:

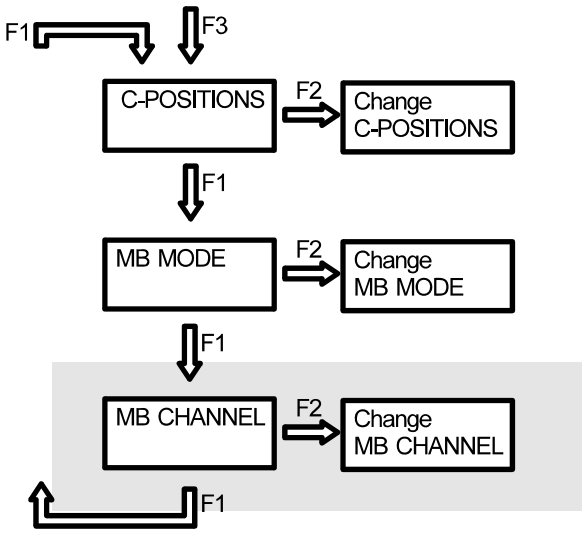
- MANUAL
- AUTOMATIC
- DCAUTO
- REMOTE
- FREEZE

When switching from MANUAL to AUTOMATIC (or DCAUTO) note the following: The current set positions are saved internally as so-called "Plasma-on" positions. These positions are assumed as soon as the matchbox has recognized that RF power is being supplied (AUTOMATIC, URF_{peak} > 5V or UDC > 5V) or that the plasma has ignited (DCAUTO, UDC > 5V). If another position is now set manually in the automatic mode via the menu CHANGE C-POSITIONS, the servos are not moved while the plasma is on. However, the user can set a position at which the plasma is certain to ignite (ignition position). In case the plasma extinguishes (e.g., at RF output "off"), this ignition position is immediately assumed.

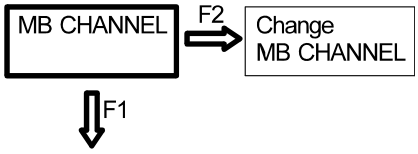
In the REMOTE operation mode, the matchbox is not controlled via the generator but via the 25-pin SUB-D connector of the matchbox.

In the FREEZE operation mode, the current actual positions of the variable capacitors in the matchbox cannot be changed.

MATCHBOX MENU: MB CHANNEL



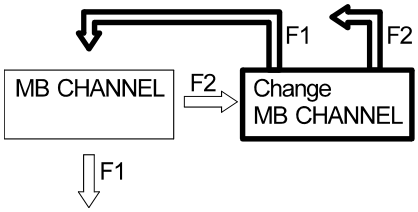
MB CHANNEL




```
CHANGE MATCHBOX: CHANNEL 1 OF 2
F1: NEXT                    F2: CHANGE
```

This menu shows which of the matchboxes (CHANNEL) is currently active.

CHANGE MB CHANNEL




```
SELECT MATCHBOX: CHANNEL 1
F1: EXIT                    F2: ENTER
```

In this menu, a Matchbox (CHANNEL) can be selected.

Notice!

You can only switch to another matchbox when the RF power is switched off. After switching, the RF output cannot be activated for about 2 s.

ADDITIONAL MENU

The following image shows the menu structure of the additional menu.

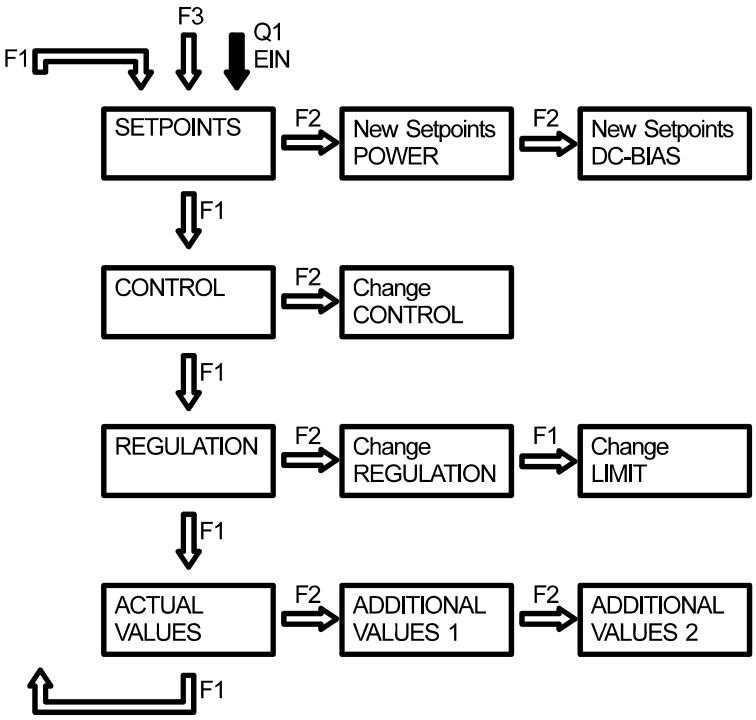
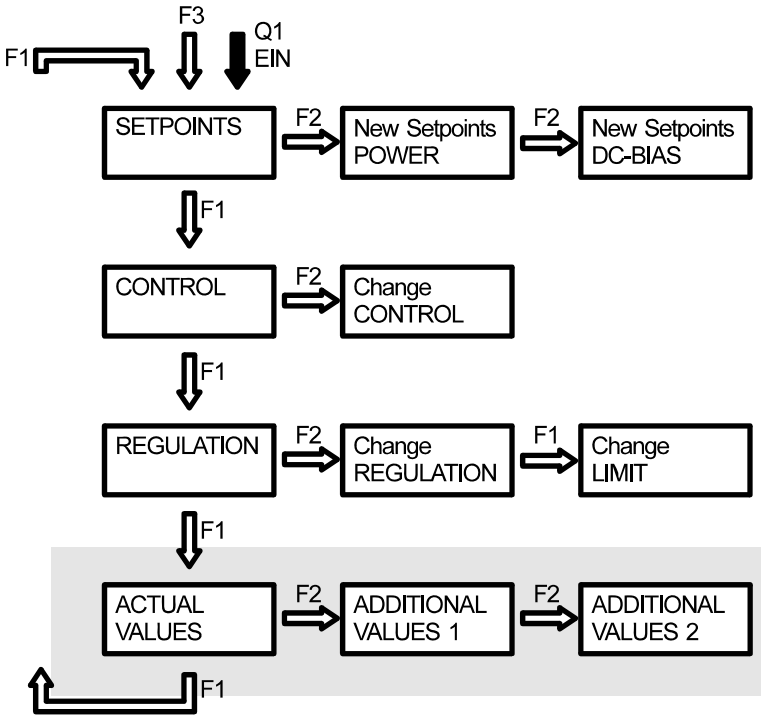


Fig. 6.8 Menu structure: Additional menu

The menu structure of the internal operation modes may be extended by an additional menu ADDITIONAL VALUES. In the additional menu, additional actual values of the generator are displayed. This is of advantage, for example, during commissioning or when dealing with critical loads.

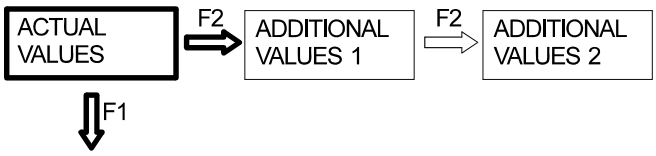
In the service menu (see section "Service menu") one can specify whether the additional menu is displayed or not.

ADDITIONAL MENU: ADDITIONAL VALUES



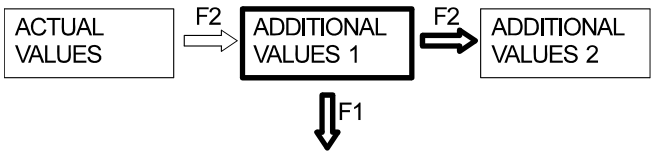
In the additional menu, additional values (ADDITIONAL VALUES) are displayed. The additional menu varies according to the generator type. Thus, the following elaborations are to be seen as examples only.

ACTUAL VALUES



In addition to the actual values, the menu ACTUAL VALUES also displays the overall running time of the generator (RF ON).

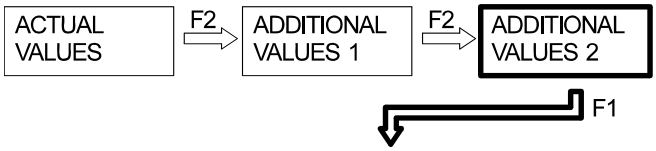
ADDITIONAL VALUES 1



PI:	0.00 kW	I10: 0.0A	I: 0.0 A
PR:	0.00 kW	UB: 0.0 V	UDS: 0.0. V

This menu displays the current actual values of the generator.

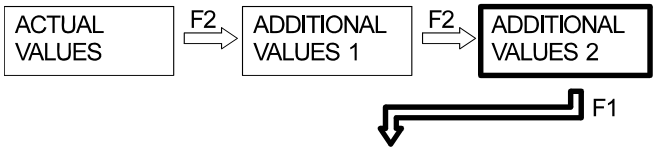
ADDITIONAL VALUES 2



PI:	0.00 kW	I1: 0.0A	I2: 0.0 A	I3: 0.0 A
PR:	0.00 kW	I6: 0.0A	I7: 0.0A	I8: 0.0A

This menu displays current actual values of the generator. Here, I1...I3 and I6...I8 are the currents of the individual final stages. Since a different number of final stages are present, depending on the generator type, the number of currents displayed varies.

ADDITIONAL VALUES 3



PI:	0.00 kW	UDC: 0 V	Z: 0	CL 500
PR:	0.00 kW	URF: 0 V	PSE: 0	CT 500

This menu displays current actual values of the generator. This menu is displayed only for generators from PFG 1600 RF onwards.

SERVICE MENU

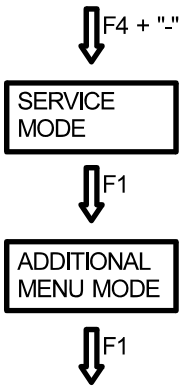


Fig. 6.9 Menu structure: Service menu

The service menu is used for service purposes, e.g., during commissioning of a generator. In the service menu, additional functions may be called. The menu cannot be accessed during normal operation. When calling functions, the following must be taken into account:

- The generator must be in one of the internal operation modes (REALTIME or REMOTE).
- The power operation must be switched off.
- The service menu can only be called via the SETPOINTS menu.

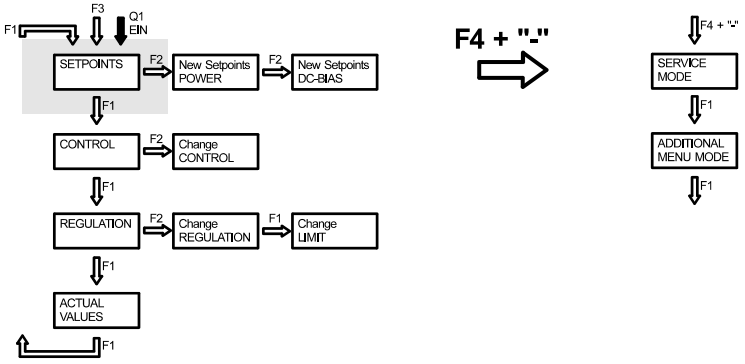


Fig. 6.10 Changing to the service menu

Calling the service menu

The service menu is called as follows:

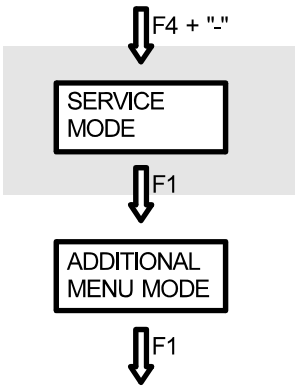
Switch the RF power off.

Change to an internal operation mode and to the menu SETPOINTS.

Simultaneously press the function key F4 and the decrement key "-" and keep them pressed for about 3 seconds.

Subsequently, the service menu appears.

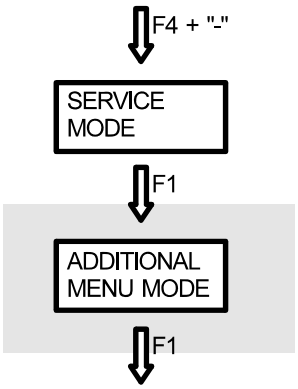
SERVICE MENU: SERVICE MODE




```
Please Setup your system!
F1: NEXT                    F2: CHANGE   SERVICE OFF
```

In this menu, you can switch on the SERVICE MODE. In the SERVICE MODE, the nominal value is no longer set by the controller, but via the potentiometer R335 on the oscillator and regulator board. This setting is meant to be active during service only and must thus always be switched to OFF.

SERVICE MENU: ADDITIONAL MENU MODE




```
Please Setup your system!
F1: NEXT      F2: CHANGE          ADD.MENUS OFF
```

In this menu, you can switch on the ADDITIONAL MENU MODE. In the ADDITIONAL MENU MODE, the menu structure of the internal operation modes is extended by the additional menu. In the additional menu, additional actual values of the generator are displayed.

6.6 TROUBLESHOOTING, RECTIFICATION OF FAULTS

FAULT MESSAGES

As soon as a fault is detected, the power operation is switched off immediately and safely if the operational state is ON. Subsequently, an appropriate error message appears on the LCD display. The lighting of the LCD display flashes. The device is secured against the reenergizing until the fault is rectified and the message is deleted by pressing F4 RESET (or via the RESET command).

Notice!

When operated via the AID interface (X1), a pending fault can only be deleted if the POWER-ON signal is reset first.

Fault messages

The following table provides an overview over the fault messages as well as information regarding cause and corrective measures.

ERROR	DESCRIPTION	CAUSE	REMEDY
01	**OVERTEMPERATURE DETECTED** The internal operational temperature has exceeded a critical limit. The system can only be reset once the operational temperature in the generator has returned to normal values.	• Ambient temperature too high. • Temperature in the generator too high.	• Provide better ventilation conditions.
02	**PREF OUT OF RANGE** For about 30 seconds, the reflected power was too high.	• Missing RF connection generator / matchbox / system • Insufficient matching by the matchbox to the system	• Check RF connection generator / matchbox / system. • Check the matching of the matchbox to the system.
03	**CURRENT TOO HIGH** For about 30 seconds, the internal operational current has exceeded the critical limit.	• Missing RF connection generator / matchbox / system • Insufficient matching by the matchbox to the system	• Check RF connection generator / matchbox / system. • Check the matching of the matchbox to the system.
04	**RF RELAY ERROR** The relay that should switch the RF power output has not engaged after pressing the ON key, or has not released after pressing the OFF key.	• Faulty relay (contact sticks).	• Contact service.
05	**POWERCOMBINER UNSYMMETRIC** (PFG 1600 ... 5000 RF only)	• Failure of a power output amplifier • Error at the power combiner	• Contact service.
06	**UDS-VOLTAGE TOO HIGH** The drain source voltage at the power output amplifier transistors was higher than 110V.	• (various reasons)	• Contact service.

Tab. 6.2 Fault messages

ERROR	DESCRIPTION	CAUSE	REMEDY
07	**CURRENT AND PR TOO HIGH** If the current of a power output amplifier has exceeded the critical value of 20A and, at the same time PR > 50 %PI, then power is switched off after about 5 seconds.	• Missing RF connection generator / matchbox / system • Insufficient matching by the matchbox to the system	• Check RF connection generator / matchbox / system. • Check the matching of the matchbox to the system.
10	**WATCH DOG ERROR DETECTED** The microcontroller has been reset. ***Warning!*** *This error must never occur during normal operation of the generator.*	• Faulty program execution or faults.	• Contact service.
11	**RAM ERROR DETECTED**	• Empty battery • Error in internal memory.	• Contact service to replace battery. • Check all values of the main menu and, if necessary, reenter them.
13	**NO COMMUNICATION ON FIBER OPTIC CABLE** The fiber optic cable connection has been interrupted	• Failure of a member • Removal of the fiber optic cable during operation.	• Re-activate member • Reestablish connection.
14	**INTERLOCK1 IS OPEN**	• Interlock1 interrupted	• Check whether all contacts in the loop of the safety circuit at Interlock1 are closed.
15	**INTERLOCK2 IS OPEN**	• A device-internal interlock is interrupted.	
16	**RF-SWITCH IS ACTIVE** The RF output is currently being switched	• There was an attempt to switch on power, although the channel switching has not been completed.	• Wait for 2 seconds and then switch on again
20	**MATCHBOX ERROR**	• General error in the matchbox	

Tab. 6.2 Fault messages

ERROR	DESCRIPTION	CAUSE	REMEDY
21	**MATCHBOX WATCHDOG**	• Watchdog of the matchbox caused a hardware reset	
22	**SLAVE ERROR**	• Error only in the case of matchbox with two processor controls. There has been an error in the "slave controller".	• Check whether servo units are blocked or heavy-going.
23	**NO REACTION ON C-TUNE**	• Tuning servo is blocked or heavy-going	• Contact service.
24	**NO REACTION ON C-LOAD**	• Load servo is blocked or heavy-going	• Contact service.
30	**RF_SWITCH FAILURE** There has been a general error in the RF selector switch	• (various reasons)	• Contact service.
31	**RF-SWITCH-RESET** The switch control has been reset by the internal Watchdog.	• Fault • Error in program execution	• Check RF connections
32	**RF-CHANNEL NOT SWITCHED** The desired channel has not been switched	• Missing acknowledgment between switch control and RF selector switch • Faulty switching output of the controller	• Check connection (all connections present)
100	**TOO MANY MEMBERS** During initialization, too many members were detected.	• The maximum number of members permitted has been exceeded	• Remove members from the ring

Tab. 6.2 Fault messages

ERROR	DESCRIPTION	CAUSE	REMEDY
101	**TOO MANY MATCHBOXES** During initialization, too many matchboxes were detected.	• There are more than 10 matchboxes connected via the fiber optic cable ring	• Remove matchbox
102	**TOO MANY SWITCHES** During initialization, too many switches were detected.	• There are more than 3 RF switching controllers on the fiber optic cable ring	• Remove RF switching controller
103	**TOO MANY CHANNELS** During initialization, the maximum number of RF switching outputs has been exceeded	• The installed RF switches and matchboxes were connected to each other in the wrong order	• Reinstall fiber optic cable connections

Tab. 6.2 Fault messages

7 MAINTENANCE

Chapter Outline:

Who is this chapter directed at?

This chapter is intended for all persons who maintain RF Generator PFG-RF on the basis of this operating manual.

Chapter contents

The chapter contains advice regarding the regular maintenance and care of the RF Generator PFG-RF.

7.1 GENERAL MAINTENANCE NOTICES

In this chapter you will find maintenance notices which describe the maintenance work necessary in order to maintain the normal operation of the generator.

All additional maintenance work beyond that described in these operating instructions is reserved for specially trained personnel and HÜTTINGER service personnel.

TECHNICAL SUPPORT

Service personnel from HÜTTINGER can be reached via the HÜTTINGER central office.

7.2 SAFE MAINTENANCE

For your own safety, you must observe the safety notices and measures described here at all times during maintenance.

KNOW THE DANGER AREAS

Life-threatening voltages!

Voltages present in the generator are life-threatening!

Make sure that you know the danger areas. For this purpose, carefully read chapter 2.4: "Danger areas: maintenance and repair" of this manual before you commence maintenance work.

REMOVING RESIDUAL VOLTAGES

Some parts of the generators retain voltage even after switching off the main switch.

Disconnect the generator before beginning maintenance work. Observe both the appropriate fundamental rules concerning working with high voltage systems as well as local and working regulations.

7.3 MAINTENANCE INTERVALS

Regular maintenance insures error-free operation

Regularly inspect the generator so that it can operate for extended periods of time and without failures. Further details are given in chapter 7.4: "Maintenance work".

The maintenance intervals are dependent on the average operating time and the corresponding environmental conditions. The given maintenance intervals are valid for single-shift operation (40 hour weeks) in a dry and low-dust environment.

MAINTENANCE INTERVALS	3 MONTHS / 500 HOURS	12 MONTHS / 2000 HOURS	4 YEARS
General visual inspection	x	x	
Cleaning	x	x	
Check fan	x	x	
Checking operating values	-	x	
Replace buffer battery			x

Tab. 7.1 Maintenance intervals

Always choose an earlier point in time

The maintenance work given in the table should be carried out if either of the two values (months or operation hours) is exceeded, i.e. after 3 months if after these 3 months less than 500 operation hours have accumulated, or after 10 weeks if after these 10 weeks the generator has already operated 500 hours.

7.4 MAINTENANCE WORK

VISUAL INSPECTION

- *Check the generator for corrosion.*
- *Check the cable terminals for color changes resulting from thermal effects.*

CLEANING

Fine dust settles in the generator which can lead to arcing.

- *Check the entire generator (particularly the cooling channel) for dust deposits.*

If dust has deposited in the generator:

- *Carefully remove the dust with a brush or vacuum cleaner.*

CHECK VENTILATORS

- *Check the fan for proper operation, unusual running noises and for ease of movement.*

CHECKING OPERATING VALUES

Together with the generator, you received a test certificate in which the factory-measured operation values are entered (see appendix with "test certificate").

Using these values, check to see if any deviations from these values have occurred.

Tools needed

In order to check the operation values, you will need:

- a 50 Ω high-frequency load resistor with a load capacity of at least the nominal output power of the generator.

Preparing for the check

You must first connect the water cooling for the 50 Ω load resistor.

Proceed as follows:

- *Connect the water intake of the 50 Ω load resistor to the drain of the generator.*
- *Connect the drain of the load resistor to the cooling system.*
- *Connect the RF power output of the generator to the load resistor.*

Carrying out the check

In order to carry out the check, you must switch on the generator and set it to power operation. Further information about this can be found in chapter 6: "Operation, control".

- *Switch on the generator.*
- *Set the output power to 0 Watts.*
- *Switch on the power operation.*
- *Compare the currently set quiescent values with those given in the test certificate.*
- *Now increase the nominal value in 25 %-steps and compare the respective values attained with the test certificate.*

Faults can be detected earlier by logging and observing deviations from values in the test certificate. The observations can also be of help if a repair is necessary.

- *Keep logs and observe the deviations from the values in the test certificate.*

Deviations of < ± 10 % from the values given in the test certificate may be tolerated.

BUFFER BATTERY REPLACEMENT

The buffer battery (lithium cell) is used for data storage when the device is switched off. (see "Control program" on page 54.) If the battery is empty, the generator starts with the default settings.

The battery is permanently soldered onto the processor circuit board. We recommend to have the battery replaced by HÜTTINGER service personnel.

7.5 REPLACEMENT PARTS

When ordering replacement parts, the following information is necessary:

- Name, type and serial number of the generator
- Assembly group of the component
- Component designation
- Part No.

Example

- For PFG 5000 RF; A46-0320; No.1-12345
- 1 piece µC card
- A20
- C40-1211

8 INTERFACES

Chapter Outline:

Who is this chapter directed at?

This chapter is intended for all persons who operate RF Generator PFG-RF on the basis of this operating manual.

Chapter contents

This chapter contains detail information about the interfaces of the RF Generator PFG-RF.

8.1 OVERVIEW OF INTERFACES

The generator is equipped with the following interfaces:

- Mains connection (X2)
- RF output (X4)
- RF input (X5)
- RF power output (P_{OUT})
- A/D interface (X1)
- RF inhibit input
- RS 232 C (X3)
- RS 485 (X6)
- PROFIBUS interface
- Fiber optic cable IN (U1), fiber optic cable OUT (U2)

In the following table, you can find a detailed assignment of the interface designations of the individual types of generators.

Interface designations

	A/D X1	RS 232 C X3	RS485 X6	P_{OUT}	Fiber optic cable U1, U2
PFG 300 RF	A8-X1	A9-X3	A9-X4	A2-X5	A8- U1, 2
PFG 600 RF	A8-X1	A9-X3	A9-X4	A10-X5	A8- U1, 2
PFG 1000 RF	-X1	-X3	- X4		- U1, 2
PFG 1600 RF	A12-X1	A13-X3	A13-X4	A10-X4	A10- U1, 2
PFG 2500 RF	A12-X1	A13-X3	A13-X4	A10-X4	A12- U1, 2
PFG 5000 RF	A20-X1	A19-X3	A19-X4	A10-X4	A20- U1, 2

Tab. 8.1 Interface designations

The interfaces are described in the following sections.

8.2 MAINS CONNECTION (X2)

PFG 300 RF

The mains supply is connected to the RF generators of type PFG 300 RF using the supplied mains cable (inlet connector for non-heating appliances).

PFG 600 RF ...
PFG 5000 RF

The mains connection of RF generators of type
PFG 600 RF … PFG 5000 RF is made for three phases using a strip terminal.

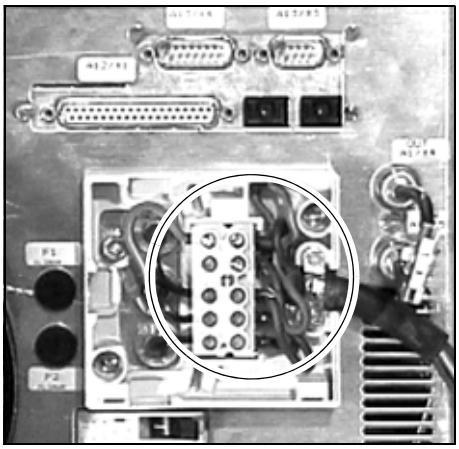


Fig. 8.1 Mains connection (X2)

8.3 RF OUTPUT (X4), RF INPUT (X5)

RF output (X4), RF input (X5)

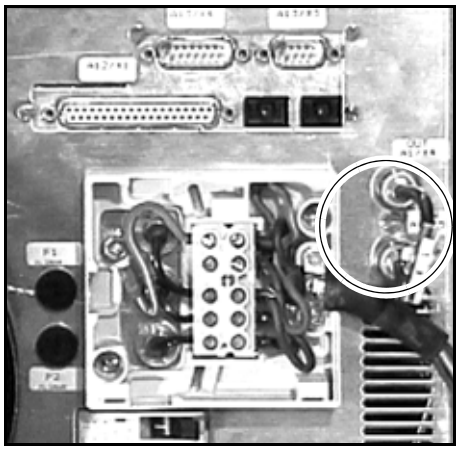


Fig. 8.2 RF output (X4), RF input (X5)

The RF input interface (X5) is a reference input. It is fed either by the generator itself or by an external master oscillator.

Feeding of the generator

If the RF input (X5) is fed by the generator and thus no external master oscillator is connected, the RF input (X5) must be connected to the RF output (X4) using a short BNC cable. When the generator is shipped, the two interfaces are already connected to each other.

Feeding by master oscillator

If a master oscillator is connected to the RF input (X5), the RF output (X4) must be equipped with a 50 Ω terminating resistor.

RF input (X5)

RF input (X5)	
Frequency	13.56 MHz
Power min.	20 mW
max.	200 mW
RF input	50 Ω (coaxial, BNC)

Tab. 8.2 RF input (X5)

8.4 RF POWER OUTPUT (P_{OUT})

RF power output

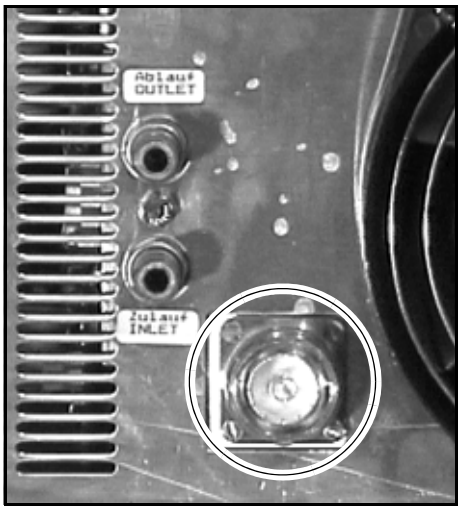


Fig. 8.3 RF power output (PFG 1600 RF, PFG 2500 RF, PFG 5000 RF)

Output data

RF POWER OUTPUT	PFG 300 RF PFG 600 RF PFG 1000 RF	PFG 1600 RF PFG 2500 RF PFG 5000 RF
Version	50 Ω coaxial, type N	50 Ω coaxial, type 7/16

Tab. 8.3 RF power output (type)

Notice!

The RF power output is named differently depending on the generator type, e.g., A2-X5 or A10-X4. For this reason, the neutral designation P_{OUT} is used for the RF power output in these operating instructions.

MATCHBOX

Recommended matchbox

Generator	Recommended matchbox
PFG 300 RF	PFM 1500 A
PFG 600 RF	PFM 1500 A
PFG 1000 RF	PFM 1500 A PFM 3000 A
PFG 1600 RF	PFM 3000 A
PFG 2500 RF	PFM 3000 A PFM 3000 Ahc
PFG 5000 RF	PFM 3000 Ahc PFM 6000 A PFM 10000 A

Tab. 8.4 Matchboxes

8.5 A/D INTERFACE (X1)

This interface can be used to remotely control the basic functions of the generator.

Data

A/D INTERFACE (X1)	
Analog inputs	
Input voltage	0 … 10 V
Input resistance ($R_{E\ min}$)	9.4 kΩ
Analog outputs	
Output resistance of the sources ($R_{I\ max}$)	6 kΩ
Admissible output current ($I_{A\ max}$)	5 mA (short-circuit proof)
Digital inputs, digital outputs	
Ext. control voltage	24 V DC
Input current (I_E)	max. 15 mA
Output current (IA)	max. 100 mA

Tab. 8.5 A/D interface (X1)

AID interface (X1),
basic circuit

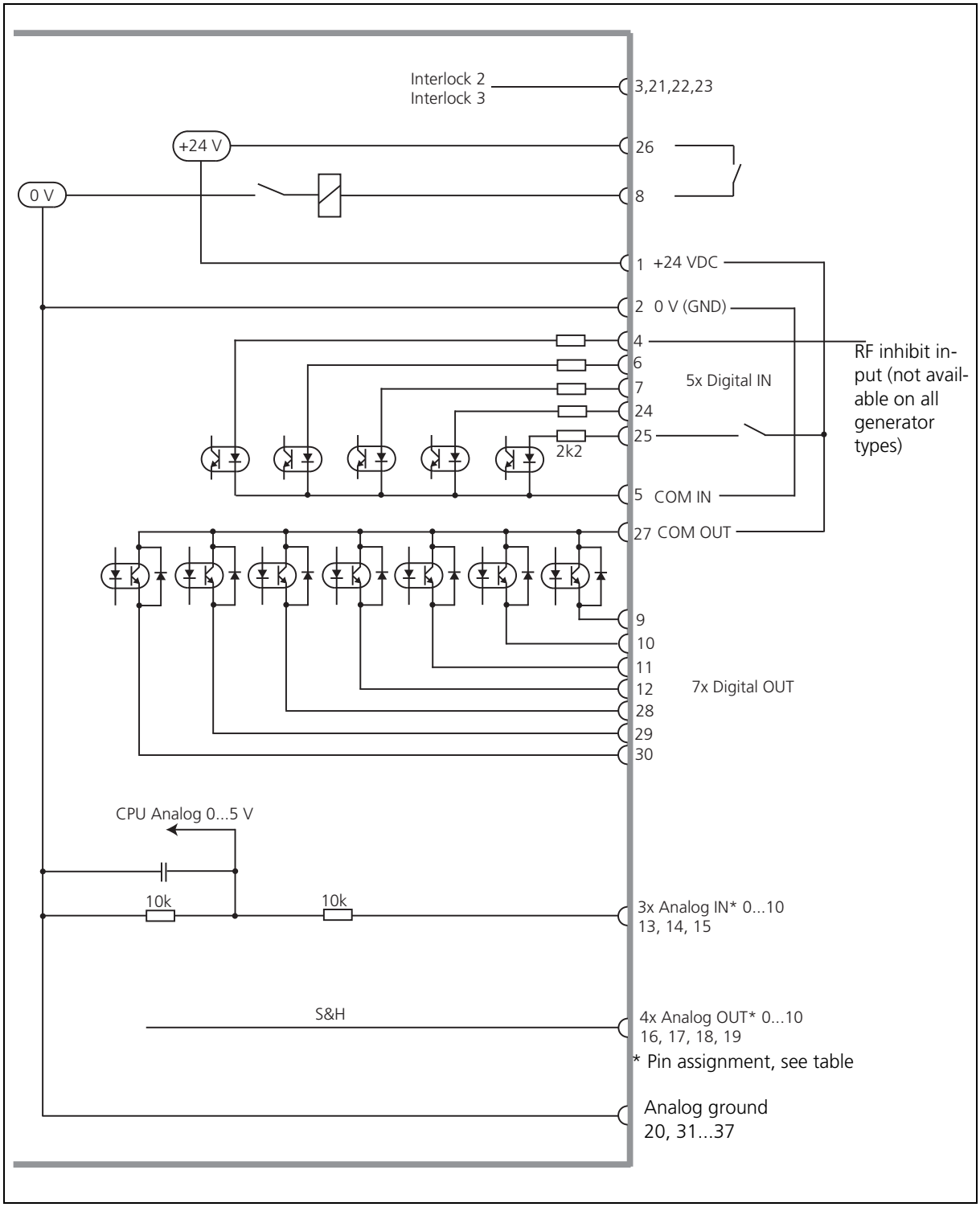


Fig. 8.4 AID interface (X1), basic circuit

A/D interface (X1)

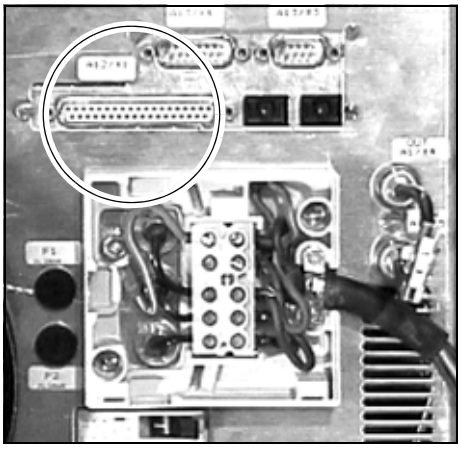


Fig. 8.5 A/D interface (X1)

The A/D interface is a 37-pin Sub-D socket with screw-type locking. A plug with pins 8 and 26 bridged (interlock1) is attached to the interface.

Warning!

When wiring the interlock, the bridge must be removed.

Warning!

The plugs and cables connected to the interface must be shielded. Connect the shielding to GND (ground).

Notice!

The term "100 % of the measured quantity" refers to the maximum value for the respective generator, i.e. the maximum possible generator current, maximum possible generator voltage, or rated generator power. The values can be found in the Technical Data.

If a voltage higher than 10 V is placed on pins 13, 14, 15, this is also interpreted as 100 %.

Analog part

A pin with analog ground (negative polarity) is assigned to each pin assigned to an analog signal. If a ribbon cable is used, these pins are located directly side by side in order to minimize possible external interference pickup.

The analog signals are scaled to a level of 0 … 10 V. Measurands and signals behave proportionally; a voltage of 10 V corresponds to 100 % of the measurand.

A/D interface (X1), assignment of analog part

PIN NO.	DESIGNATION	MEANING
Inputs		
14	AV U_{DC} +	Actual value DC BIAS voltage
32	AV U_{DC} -	
15	NV P_I + / NV U_{DC} +	Nominal value of direct power / DC BIAS voltage
33	NV P_I + / NV U_{DC} -	
13	NV U_{DC} +	Nominal value DC BIAS voltage (in REMOTE3 only)
31	NV U_{DC} -	
Outputs		
17	AV I +	Actual value of operating current
35	AV I -	
18	AV P_R +	Actual value of reflected power
36	AV P_R -	
19	AV P_I +	Actual value of direct power
37	AV P_I -	
16	AV U_{DC} +	Actual value DC BIAS voltage
34	AV U_{DC} -	
Supply area		
1	+ 24VDC	Control voltage (+24 V)
2	GND	Ground (+0 V)
20	GND	Ground (+0 V)

Tab. 8.6 A/D interface (X1), assignment of analog part

The pins 2, 20, 31 to 37 are connected internally and form the analog ground (GND).

DIGITAL PART

AID interface (X1), assignment of digital part

PIN NO.	DESIGNATION	MEANING
Inputs		
25	POWER ON	Power on
6	E1	Switching the regulation
24	E2	Switching the limit
7	RESET	Delete error message
4	RF-INHIBIT	Keying input (not available on all generator types)
5	COM IN	Reference potential of inputs
Outputs		
12	STANDBY	Readiness for operation
30	POWER ON	Message: Power on
28	EXTERN	External operating mode
10	Fault	Accumulated error messages
11	P_R >	Error message
Reflected power		
29	I >	Error message
Operating current		
27	COM OUT	Reference potential for outputs
Interlock input		
8	Interlock1 (+24 V in)	Interlock1
26	Interlock1 (+24 V out)	
Interlock outputs		
3	Interlock2	Interlock2
21	Interlock2	(break contact)
22	Interlock3	Interlock3
23	Interlock3	(make contact)

Tab. 8.7 AID interface (X1), assignment of digital part

PIN NO.	DESIGNATION	MEANING
Reserved area		
9	Reserved	

Tab. 8.7 A/D interface (X1), assignment of digital part

The digital inputs (except for interlock1) are floating. This is achieved via optical couplers and is designed for an external control voltage of 24 VDC. The common reference potential of the inputs is pin 5 (COM IN).

The outputs (except for interlock2 and interlock3) are designed as NPN transistors with tapped emitters (+24 V, positive logic). The common reference potential of the outputs is pin 27 (COM OUT).

For permitted loads on the interface, see Tab. 8.5 on page 105.

Setting: Regulation mode

The selection of the regulation mode via the A/D interface (X1) is limited. The selection can only take place in combination with the menu or with a serial interface.

Depending on whether the regulation mode was preset to power or voltage via the menu (or via a serial interface), the final regulation mode can be selected via Input E1. Input E2 is used to set which variable is selected as the limit. The options for the selection are shown in the following table.

REGULATION MODE				
Setting *	Regulation mode (E1)		Limit (E2)	
	0 V	+24V	0 V	+24V
P	POWER	DELTA-P	U_{DC}	RF_{PEAK}
U	DC BIAS	RF PEAK	P_I	ΔP
***P** "power" regulation mode preset (either via the menu REGULATE=POWER or DELTA-P or via RS232 or RS485: REGULATE=1) **U** "voltage" regulation mode preset (either via menu REGULATE=DC-BIAS or RF-PEAK or via RS232 or RS485: REGULATE=2)				

Tab. 8.8 Setting: Regulation mode

INTERLOCKS

Interlocks

The generator is equipped with 3 interlock connections.

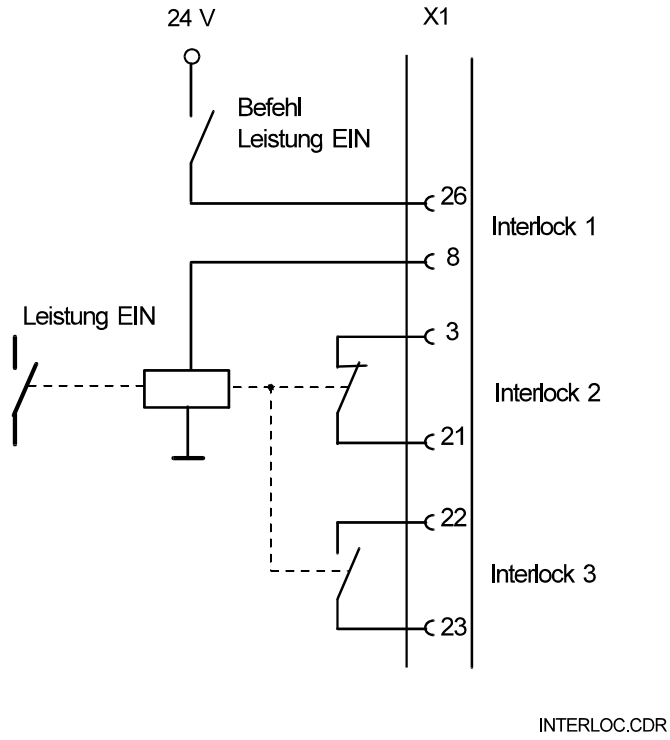


Fig. 8.6 Interlocks (circuit diagram)

Interlock 1 (input)

Connection of an external safety switch for interrupting power operation. Interlock1 is to be wired with potential-free contacts. No external voltages may be connected. Interlock 1 must be closed to be able to operate the generator.

Interlock 2 (message) (output)

Floating contact of the "power on" relay for locking external circuits. In power operation, this contact is open.

Interlock 3 (message) (output)

Floating contact of the "power on" relay for locking external circuits. In power operation, this contact is closed.

RF INHIBIT INPUT

The INHIBIT signal is a keying signal. With low level (open input), power is delivered; with high level, no power is delivered. The amplitude of the output signal is not impaired by the amplitude of the keying signal.

Specification: RF inhibit input

RF inhibit input		
Max. pulse frequency:	f_{mod}	~5000 Hz (t_{min} ~ 200 µs)
Rise time of the RF signal	t_{rise}	~35 µs
Fall time of the RF signal	t_{fall}	~35 µs
Input voltage	U	24 V (A/D interface) / 5 V (SUB MINUX socket)

Tab. 8.9 Specification: RF inhibit input

Signal shape

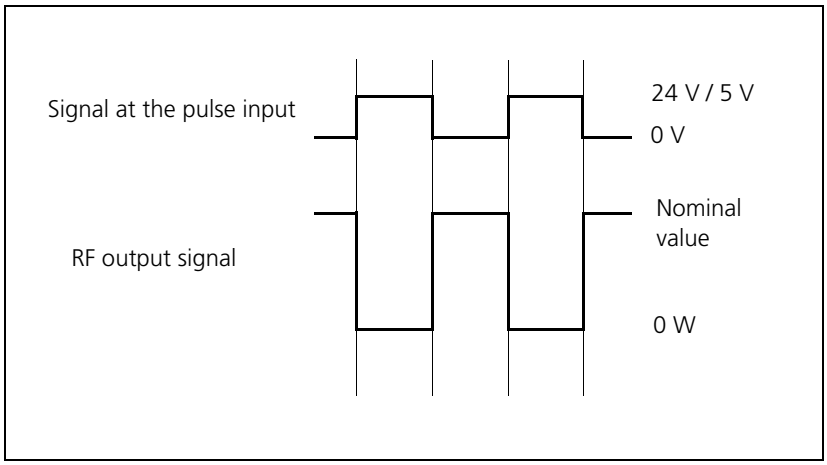


Fig. 8.7 Signal curve RF inhibit input

The display of the P_I (and P_R) is an approximate mean value display, i.e. not a peak value display! Example: At a nominal value (amplitude) maximum of 600 W and a duty cycle of approx. 50%, the display shows approx. 250 - 300 W for P_I.

Signal shape at f_{mod} = 5 kHz TV = 50 %

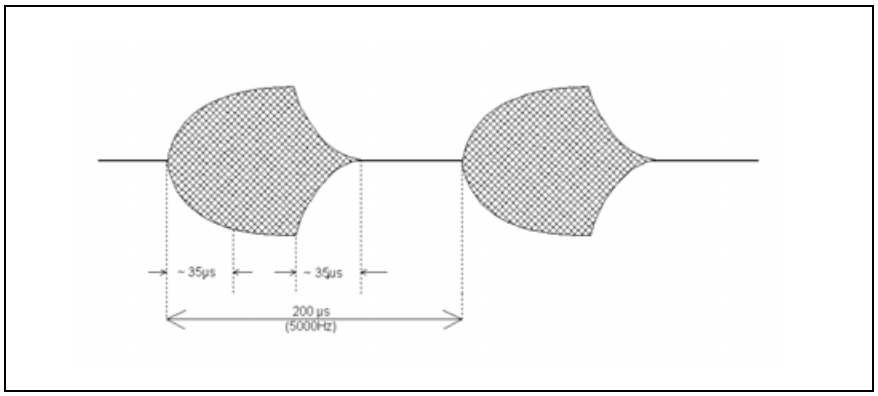


Fig. 8.8 Signal shape: RF inhibit input

PR behavior:slight overshoot in the µs range, regulation towards the mean value, but no switch-off at TV <~ 80 % !

8.6 RF INHIBIT INPUT / SUB-MINUX

PFG 600 and PFG 1000 are optionally equipped with an RF inhibit input via a SUB MINUX socket. The function corresponds to the RF inhibit input via the A/D interface.

See "RF inhibit input" on page 111

8.7 RS 232 C (X3)

The RS 232 C interface can be used to read and write all generator control and measurement signals.

Data

RS 232 C INTERFACE (X3)	
LOGIC	LEVEL
Input voltage D_{in}	
0	+ 3 V ... + 15 V
1	- 3 V ... - 15 V
Output voltage D_{out}	
0	+ 9 V
1	- 9 V
TRANSMISSION SPEED	
Baud rate	9600 baud (± 0.5 %)

Tab.8.10 RS 232 C interface (X3)

RS 232 C interface (X3)

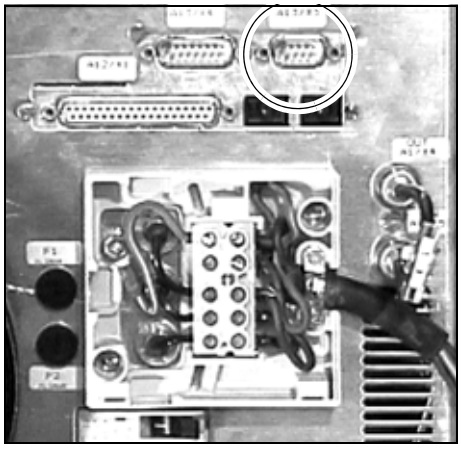


Fig. 8.9 RS 232 C interface (X3)

The RS 232 C interface is a 9-pin Sub-D socket with screw-type locking.

Warning!

The plugs and cables connected to the interface must be shielded. The shielding must be connected to the housing ground. Use a suitable plug for this connection.

The serial connection of the generator to a host is illustrated in the following connection diagram.

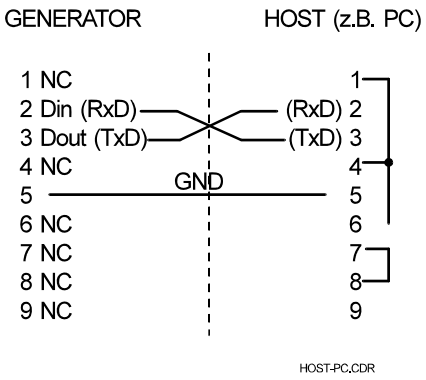


Fig. 8.10 Serial connection (connection diagram)

RS 232 C interface (X3), assignment

PIN NO.	ASSIGNMENT
2	D_{in} (data input)
3	D_{out} (data output)
5	GND (ground)

Tab. 8.11 RS 232 C interface (X3), assignment

The connection assignments are in accordance with the RS 232 C standard.

The interface forms a point-to-point connection. Data transmission takes place asynchronously at a bit rate of 9600 baud (±0.5 %).

RS 232 C interface (X3), 5-byte communication block

The serial data transmission of the entire Hüttinger line of equipment is based on a uniform communication block. It consists of 5 bytes:

- 1 address byte (fiber optic cable)
- 1 function byte
- 2 data bytes
- 1 check byte

The exact arrangement of the communication block is given in the following table.

5 BYTE COMMUNICATION BLOCK						
ADDRESS BYTE	**FUNCTION BYTE**			**DATA BYTES**		**CHECK BYTE**
				HIGH BYTE	**LOW BYTE**	
AAAA AAAA	WFFF FFFF			DDDD DDDD	DDDD DDDD	PPPP PPPP
GENERATOR COMMANDS						
ASCII	**HEX**	**COMMAND**		**MEANING**		
A	41H	NV PI	set	Nominal value of direct power (W) (for the PFG 5000 RF, set in steps of 10 watts; otherwise, set in steps of 1 watt)		
	C1H		query			
B	42H	NV U_{DC}	set	Nominal value of DC-BIAS voltage (V) (if the fiber optic cable bus is not used, the setting must be made in 0 … 1000 ‰)		
	C2H		query			
G	47H	CHANNEL	set	Selection of the matchbox that is to be supplied with RF power.		
	C7H		query			
M	4DH	REGULATE	set	Regulation mode (1=POWER, 2=DC-BIAS, 3=DELTA-P, 4=RF-PEAK)*		
	CDH		query			
N	-	CONTROL	-	Operating mode (1=LOCAL, 2=REALTIME, 3=RS232, 4=REMOTE1, 5= REMOTE2, 6=RS485, 7=PROFIBUS, 8=REMOTE3, 9=REMOTE4)		
	CEH		query			
O	4FH	Operating state	set	Operating state (0=OFF: power operation off, 1=ON: power operation on)		
	CFH		query			
	D1H	AV P_I	query	Actual value of direct power (W) (for the PFG 5000 RF, display is in steps of 10 watts; otherwise, display is in steps of 1 watt)		
	D2H	AV UDC	query	Actual value of DC-BIAS voltage (V) (if the fiber optic cable bus is not used, the voltage is displayed in 0 … 1000 ‰)		
	D4H	AV PR	query	Actual value reflected power (W)		

Tab. 8.12 5-byte communication block (RS 232 C)

5 BYTE COMMUNICATION BLOCK					
W	57H	Limit	set	Limit (1=POWER, 2=DC-BIAS, 3=DELTA-P, 4=RF-PEAK)*	
	D7H		query		
X	58H	NV RFPEAK	set	Nominal value of RF peak voltage (if the fiber optic cable bus is not used, the setting must be in 0 … 1000 ‰)	
	D8H		query		
	D9H	AV RFPEAK	query	Actual value of RF peak voltage (if the fiber optic cable bus is not used, the setting is in 0 … 1000 ‰)	
	DAH	error	query	For errors: error number** otherwise: zero	
P	50H	RESET		Delete error message	
AUTOMATIC MATCHBOX COMMANDS					
ASCII	**HEX**	**COMMAND**		**MEANING**	
E	45H	NV CT	set	Set position tuning capacitor (0 … 1000 ‰)	
	C5H		query		
F	46H	NV CL	set	Set position load capacitor (0 … 1000 ‰)	
	C6H		query		
G	47H	CT_BRPOS	set	"Plasma-on" position tuning capacitor (0 … 1000 ‰)	
	C7H		query		
H	48H	CL_BRPOS	set	"Plasma-on" position load capacitor (0 … 1000 ‰)	
	C8H		query		
M	4DH	MB_MODE	set	Matchbox mode (1=MANUAL, 2=AUTOMATIC, 3=REMOTE, 4=FREEZE, 5=DCAUTO)	
	CDH		query		
	D5H	AV CT	query	Actual position tuning capacitor (0 … 1000 ‰)	
	D6H	AV CL	query	Actual position load capacitor (0 … 1000 ‰)	
P	50H	RESET		Delete error message	
	06H	ACK		-	
	15H	NAK		-	

Tab. 8.12 5-byte communication block (RS 232 C)

5 BYTE COMMUNICATION BLOCK
A address bits (fiber optic cable) **W** wait bit **F** function bits **D** data bits **P** check bits For the generators, 00 is always entered for the **address byte (fiber optic cable)**. The **function byte** consists of 1 wait bit and 7 function bits. The **wait bit** indicates whether a write or read command is at hand. Each byte (8 bits) is completed with one **start bit** and one **stop bit**: 1 start bit | 8 bits | 1 stop bit **ACK**=Acknowl.function: Correct Reception (ASCII: 06h) **NAK**=Not Ackn.function: Incorrect Reception (ASCII: 15h) * see table 8.8, "Setting: Regulation mode," on page 110. ** The error numbers are listed in section chapter 6.6: "Troubleshooting, rectification of faults".

Tab. 8.12 5-byte communication block (RS 232 C)

Transmission protocol, description

1. The host always sends a complete communication block (5 bytes long). Address identification is, in general, set to 0 for generators.
2. The contacted device accepts the communication block and calculates a new checksum from the first 4 bytes. If the calculated checksum does not correspond to the one received, a transmission error has occurred. In this case, the device responds with an answer block (5 bytes long) in which the second character is a "NAK". This way the host can detect the transmission error and, in general, repeat transmission of the communication block.
3. The checksums usually correspond. The device now checks the wait bit. For write commands (wait bit=0), no numerical value is expected back. In these cases, a simple acknowledgment suffices: the device sends an answer block (5 bytes long) in which the second character is an "ACK". This way the host can recognize that the control command has been correctly received and that the transmission is at this point complete. For read commands (wait bit=1), on the other hand, a numerical value is expected back. In these cases, the device returns an answer block which contains neither "NAK" nor "ACK", but the function byte (with wait bit=0) and the requested numerical value. The host can accept the value and the transmission is complete. All numerical values are sent in the form of a 16-bit binary number without sign.

Default nominal value (example)

HOST ------> 00h | 41h | 00h | FFh | BEh------> DEVICE

Set nominal value for direct power to 255 W!

DEVICE------> 00h | 06h | 00h | 00h | 06h------> HOST

Acknowledge!

Calculation of the checksum

The checksum is made up of XOR-links of the 4 bytes of the communication block:

Address byte XOR function byte XOR data byte 1 XOR data byte 2 = check byte

Example:

00H XOR 41H XOR 00H XOR FFH = BEH

RS 232 interface (capacity)

The pure transmission time per communication block (5 bytes) is, at a transmission rate of 9600 baud, approximately 5 ms. As two communication blocks are transmitted per transaction, the total time is approximately 10 ms. Up to 100 transactions can, therefore, be processed in one second.

8.8 RS 485 (X6)

The RS 485 C interface can be used to read and write all generator control and measurement signals.

Data

RS 485 INTERFACE (X6)	
LOGIC	LEVEL
Input voltage D_{in}	
$\lvert D_{in}+ - D_{in}- \rvert$	0.2 V ... 12 V
Output voltage D_{out}	
$\lvert D_{out}+ - D_{out}- \rvert$	1.5 V ... 5 V
TRANSMISSION SPEED	
Baud rate	9600 baud (± 0.5 %)

Tab. 8.13 RS 485 interface (X6)

RS 485 interface (X6)

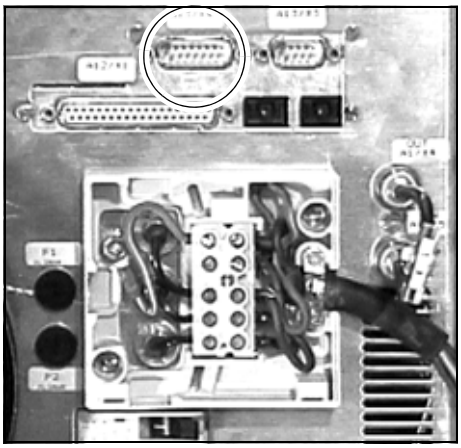


Fig. 8.11 RS 485 interface (X6)

The RS 485 C interface is a 15-pin Sub-D socket with screw-type locking.

Warning!

The plugs and cables connected to the interface must be shielded. The shielding must be connected to the housing ground. Use a suitable plug for this connection.

RS 485 interface (X3), assignment

PIN NO.	ASSIGNMENT
1	shield
2	D_{out} + (data output)
4	D_{in} + (data input)
8	GND (ground)
9	D_{out} - (inverted data output)
11	D_{in} - (inverted data input)

Tab.8.14 RS 485 interface (X3), assignment

The connection assignments correspond to the RS 485 standard and ship as 4-wire interface (2 transmitting, 2 receiving lines). If a 2-wire connection is required, this can be achieved externally in the plug by connecting pins X4/2 to X4/4 (non-inverting line) and pins X4/9 to X4/11 (inverting line). The same may be accomplished internally by setting the bridges W5 and W6 of the interface card (C40-1377) appropriately. In order to do this, however, the unit must be opened. In this case, the respective pins in the plug need not be connected. Note that an inverting and a non-inverting signal are each used in the plug.

The interface forms a point-to-point connection. The connection consists of: 2 transmitting lines, 2 receiving lines, signal ground and shield. The data transfer takes place half duplex asynchronously with a bit rate of 9600 baud (±0.5%). Each command request by the "Master" (e.g., PC) is followed by a response from the "Slave" (generator). This response must be waited for. Between a response and a new command request, there must be a wait time of at least 50 ms. If this time is not allowed to pass before the next request is made, a "framing error" warning message is output by the generator.

Synchronization of the data connection

The actual data exchange is performed with a protocol similar to the one used for an RS232 connection. The problem here, however, is the synchronization of the data stream in all connected generators, as the protocol itself does not contain any intrinsic control bytes (data are transmitted in a pure binary form). For this reason, if the RS 485 interface is used, a synchronization sequence must be output by the host computer before every transmission. The synchronization sequence consists of at least four bytes with value FFH.

The data stream then appears as follows on the bus line:

FFH	FFH	FFH	FFH	7-byte communication block (host)	7-byte response (generator)	Pause

A pause of at least 50ms must be maintained between such a data exchange and the subsequent transmission, as this time is needed before the generator releases the bus again. If no synchronization is performed by the master, there is no response to the protocol.

RS 485 interface (X6), 7-byte communication block

The serial data transmission via the RS 485 interface is based on a uniform communication block. It consists of 7 bytes:

- 1 address byte (RS 485 receiver)
- 1 address byte (RS 485 transmitter)
- 1 address byte (fiber optic cable)
- 1 function byte
- 2 data bytes
- 1 check byte

The exact structure of the data format (7 bytes) has to be observed as the synchronization of the data exchange is accomplished exclusively via the number of bytes received/transmitted. This applies in particular to the connection of the generator with devices that do not use the "Hüttinger format"!

To interconnect different devices on a bus, the use of an interface with a standardized protocol layer is recommended, e.g. Profibus.

The exact arrangement of the communication block is given in the following table. The description of the command block (function byte) can be found in the description of the RS-232 interface.

<table>
<tr><th colspan="7">7-BYTE COMMUNICATION BLOCK</th></tr>
<tr><th rowspan="2">ADDRESS BYTE (RECEIVER)</th><th rowspan="2">ADDRESS BYTE (TRANSMITTER)</th><th rowspan="2">ADDRESS BYTE (FOC)</th><th rowspan="2" colspan="2">FUNCTION BYTE</th><th colspan="2">DATA BYTES</th><th rowspan="2">CHECK BYTE</th></tr>
<tr><th>HIGH BYTE</th><th>LOW BYTE</th></tr>
<tr><td>EEEE EEEE</td><td>SSSS SSSS</td><td>LLLL LLLL</td><td colspan="2">WFFF FFFF</td><td>DDDD DDDD</td><td>DDDD DDDD</td><td>PPPP PPPP</td></tr>
<tr><td></td><td></td><td></td><td>HEX</td><td>COM-MAND</td><td colspan="2">MEANING</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="4">(The meanings of the function bytes and the data bytes are described in Tab.8.12 5-byte communication block (RS 232 C).)</td><td></td></tr>
</table>

Tab.8.15 7-byte communication block (RS 485)

7-BYTE COMMUNICATION BLOCK
E address bits (RS 485 receiver) **S** address bits (RS 485 transmitter) **L** address bits (fiber optic cable) **W** wait bit **F** function bits **D** data bits **P** check bits The addresses of the participants in the RS-485 ring are entered as **address byte (RS 485)**. For the generators, 00 is always entered for the **address byte (fiber optic cable)**. The **function byte** consists of 1 wait bit and 7 function bits. The wait bit indicates whether a write or read command is at hand. The **data bytes** consist of 1 high byte and 1 low byte. The **check byte** is an exclusive-OR operation of the previous 6 bytes. Each byte (8 bits) is completed with one **start bit** and one **stop bit**: 1 start bit | 8 bits | 1 stop bit

Tab. 8.15 7-byte communication block (RS 485)

8.9 PROFIBUS INTERFACE

GENERAL

Profibus interface X3, assignment

The connection to the Profibus takes place via a 9-pin SUB-D socket. The pins are assigned as follows:

PIN NO.	ASSIGNMENT
3	$D_{in/out}$ + (positive data line)
5	GND (ground)
8	$D_{in/out}$ - (negative data line)

Tab. 8.16 Profibus interface (X3), assignment

Intelligent slave

The Profibus interface is configured for an intelligent slave. The sizes of the input and output buffers are listed in Tab. 8.17 on page 125.

TYPE	NUMBER	CODING
digital "inputs"	2 (2*1 byte)	011h
analog "inputs"	6 (6*2 bytes)	055h
length D_IN_Buffer	Byte 14	
digital "outputs"	2 (2*1 byte)	021h
analog "outputs"	4 (4*2 bytes)	063h
length D_OUT_Buffer	10 bytes	

Tab.8.17 Lengths of the PROFIBUS input and output buffers

The read data as well as the write data are divided into "digital" (1 byte) and "analog" (2 byte) data words. The "digital" words are either bit-sorted (every bit has a certain meaning) or are to be evaluated as an 8-bit number (e.g. error status). The "analog" words are to be interpreted as 16-bit values which are divided into a high byte and a low byte.

Notice!

When writing the data, remember that all values are always transmitted. A transmission containing, for example, only changed values is not possible.

Settings on the master

- The settings are contained in the GSD file included in the delivery.
- Adjustment of the activity monitoring of the participant's watchdog.
- The PNO-Ident number is 0726.
- No member-specific parameter bytes are used.
- The settings for the configuration telegram must be carried out as described in Tab.8.17 on page 125.
- Synchronous and freeze operation are not provided.

Generator with matchbox

If a generator with matchbox is controlled, the following has to be taken into account:

- The process number (CHANNEL, command byte1) must be set to at least 1, even if no matchbox is connected.
- As long as the reset bit (command byte2, bit2) is set, no changes are accepted via the PROFIBUS.
- Before an error can be reset, the RF-ON bit (command byte 2, bit0) must be set to 0 (=power off).
- Before the generator can be connected to the PROFIBUS, the generator must be set to a free PROFIBUS address.

DEFINITION OF THE "OUTPUTS" ON THE PROFIBUS

The command bytes with the nominal values that are sent from the PROFIBUS to the RF generator are listed in Tab.8.18 on page 126.

COMMAND BYTES	MEANING
Byte 1	Process number (CHANNEL)
Byte 2	Commands
Byte 3+4	Nominal power value
Byte 5+6	Nominal voltage value
Byte 7+8	Tune position
Byte 9+10	Load position

Tab.8.18 Overview of the PROFIBUS command bytes

Command byte 1 - process number (CHANNEL)

COMMAND BYTE 1 - process number (CHANNEL)							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
NU	NU	NU	NU	2^3	2^2	2^1	2^0

Tab.8.19 Command byte 1 - process number

This byte tells the generator or the RF selector switch which process (CHANNEL) is to be addressed. If this number does not match the current process, the system switches to the new process, provided that the RF output of the generator is not activated. Otherwise, no action takes place. The maximum number that can be entered here is 10, provided that this is permitted by the installed system. In the generator, the transmitted value is checked for plausibility. See also Generator with matchbox.

Command byte 2 - commands

COMMAND BYTE 2 - COMMANDS							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PFM_FREEZE	PFM_CTRL	NU	U_CTRL	P_CTRL	RESET	RSVE	RF_ON
MEANING							
RF_ON		Switch contactor on and off					
	0	Switch contactor off					
	1	Switch contactor on					
RSVE		Reserved for oscillator enable					
	0	Enable oscillator					
	1	Disable oscillator					
RESET		Delete pending errors					
	0	(no action)					
	1	Delete pending errors					
P_CTRL		Power regulation mode					
	0	Power regulation towards P_I (POWER)					
	1	Regulation towards $P_I + P_R$ (DELTA-P)					
U_CTRL		Voltage regulation mode					
	0	UDC regulation (DC-BIAS)					
	1	RF_{peak} regulation (RF-PEAK)					
NU		(not used)					
PFM_CTRL		Matchbox mode					
	0	Manual (go to nominal position values)					
	1	Automatic (motors move according to Z or f signals)					
PFM_FREEZE		Freeze mode (motors remain at their current actual position)					
	0	Normal operation					
	1	"Freeze" motors at the actual positions					

Tab. 8.20 Command byte 2 - commands

Command bytes 3 + 4 - nominal power value

COMMAND BYTES 3 AND 4 - NOMINAL POWER VALUE							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Tab. 8.21 Command bytes 3 + 4 - nominal power value

The nominal power value is transmitted as a 16-bit word. The value is preset as a real power value in integer watt steps (e.g., 1650 for 1650 watts direct power). Up to PFG 2500 RF, the specification is made in steps of 1 watt. For the PFG 5000 RF, the power specification must be in steps of 10 watts: e.g., 200 must be preset for 2000W.

The maximum value depends on the generator type. Other values are not accepted by the generator software.

Command bytes 5 and 6 - nominal voltage value

COMMAND BYTES 5 AND 6 - NOMINAL VOLTAGE VALUE							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Tab. 8.22 Command bytes 5 and 6 - nominal voltage value

The nominal voltage value is a 16-bit word. The voltage range is defined from 0V to 2040V.

Command bytes 7 and 8, command bytes 9 and 10 - nominal position value tuning capacitor, load capacitor

COMMAND BYTES 7 AND 8 - NOMINAL POSITION VALUE TUNING CAPACITOR							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Tab.8.23 Command bytes 7 and 8 - nominal position value tuning capacitor

COMMAND BYTES 9 AND 10 - NOMINAL POSITION VALUE LOAD CAPACITOR							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Tab.8.24 Command bytes 9 and 10 - nominal position value load capacitor

The two nominal position values have a value range from 0 to 1000, which equals a positioning in 0.1% of the total capacitor capacity. After the adjustment time, these values are in line with the actual positions in question.

DEFINITION OF THE "INPUTS" ON THE PROFIBUS

The status bytes with the actual values that are sent from the RF generator to the PROFIBUS are listed in Tab. 8.25 on page 130.

Status bytes	MEANING
Byte 1	Generator status
Byte 2	Error number (ERROR)
Byte 3+4	AV P_I
Byte 5+6	AV P_R
Byte 7+8	AV $U_{DC-BIAS}$
Byte 9+10	AV RF_{PEAK}
Byte 11+12	Tune position (tuning capacitor)
Byte 12+13	Load position (load capacitor)

Tab. 8.25 Overview PROFIBUS status bytes

Status byte 1 - generator status

STATUS BYTE 1 - GENERATOR STATUS							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
NU	NU	SW_ STAT	PLAS MA	NU	NU	CTRL	RF_ ON

MEANING	
RF_ON	State of the RF power
0	Power is switched off
1	Power is switched on
CTRL	Type of generator control
0	Control via the operator panel
1	Control via PROFIBUS
NU	(not used)
NU	(not used)
PLASMA	State of the RF space (plasma chamber)
0	No plasma ignited (no UDC voltage present)
1	Plasma has ignited
SW_ STAT	State of the RF selector switch
0	RF selector switch not active

Tab. 8.26 Status byte 1 - generator status

STATUS BYTE 1 - GENERATOR STATUS	
1	RF selector switch is currently switching
NU	(not used)
NU	(not used)

Tab.8.26 Status byte 1 - generator status

Status byte 2 - error number

STATUS BYTE 1 - ERROR NUMBER (ERROR)							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Tab.8.27 Status byte 1 - error number

This byte shows the state of the generator. If this byte equals 0 (all bits LOW), then the generator is operational. If this byte is not equal to 0, then the generator has interrupted power operation (if activated) and reports this via the appropriate error number.

Status bytes 3 and 4 - actual power value

STATUS BYTES 3 AND 4 - ACTUAL POWER VALUE (AV P_I)							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Tab.8.28 Status bytes 3 and 4 - actual power value

The actual power value (AV P_I) is transmitted as a 16-bit word. The value is available to the user as a real power value as an integer number of watts. The maximum value depends on the generator type.

Status bytes 5 and 6 - reflected power

STATUS BYTES 5 AND 6 - REFLECTED POWER (AV P_R)							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0

Tab.8.29 Status bytes 5 and 6 - reflected power

STATUS BYTES 5 AND 6 - REFLECTED POWER (AV P_R)							
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Tab. 8.29 Status bytes 5 and 6 - reflected power

This value shows the current reflected power (AV PR). It is an indicator for the quality of the match. The maximum value depends on the power class of the generator and can reach up to 20 % of the possible direct power P_I (Example PFG 1000 RF: P_{Rmax} = 0.2 * 1000 W = 200 W).

Status bytes 7 and 8 - plasma voltage U_{DC}

STATUS BYTES 7 AND 8 - PLASMA VOLTAGE U_{DC}							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Tab. 8.30 Status bytes 7 and 8 - plasma voltage

The voltage range U_{DC} is defined from 0 V to 2040 V. If the generator is operated without the fiber optic bus, then the value must be specified as 0 … 1000 ‰.

Status bytes 9 and 10 - RF_{peak} voltage

STATUS BYTES 9 AND 10 - RFPEAK VOLTAGE							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Tab. 8.31 Status bytes 7 and 8 - plasma voltage

The voltage range RF_{peak} is defined from 0 V to 2040 V. If the generator is operated without the fiber optic bus, then the value must be specified as 0 … 1000 ‰.

Status bytes 11 and 12, status bytes 13 and 14 - actual position values tuning capacitor, load capacitor

STATUS BYTE 11 AND 12 - ACTUAL POSITION VALUE TUNING CAPACITOR							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Tab. 8.32 Status bytes 11 and 12 - position value tuning capacitor

STATUS BYTE 13 AND 14 - ACTUAL POSITION VALUE LOAD CAPACITOR							
HIGH BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
LOW BYTE							
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Tab. 8.33 Status bytes 13 and 14 - position value load capacitor

The two actual position values must match the preset nominal positions of the capacitors (±2 digits).

8.10 FIBER OPTIC CABLE IN (U2), FIBER OPTIC CABLE OUT (U1)

The fiber optic interface is used to connect the generator to the fiber optic ring.

Fiber optic cable In (U2), Out (U1)

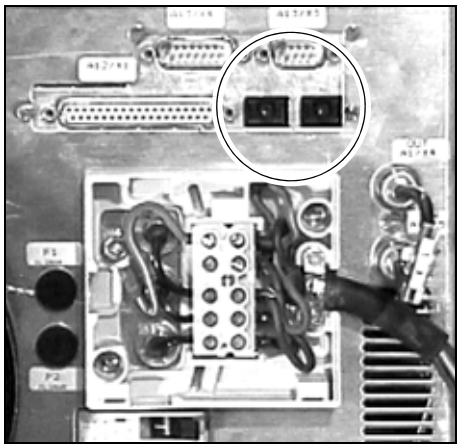


Fig. 8.12 Fiber optic cable In (U2), Out (U1)

The fiber optic interfaces are of the Toshiba Toslink type.

STRUCTURE OF THE FIBER OPTIC RING

The fiber optic ring is used to exchange measurement values and control signals between the RF generator, the matchbox and additional components. The RF generator coordinates the operation of the functions.

Notice!

When constructing a fiber optic ring, you must take care to first chain the RF selector switch and then the matchboxes into the fiber optic ring.

The specification of the fiber optic addresses varies according to the sequence in the fiber optic ring. The following figure provides an example for the construction of a fiber optic ring.

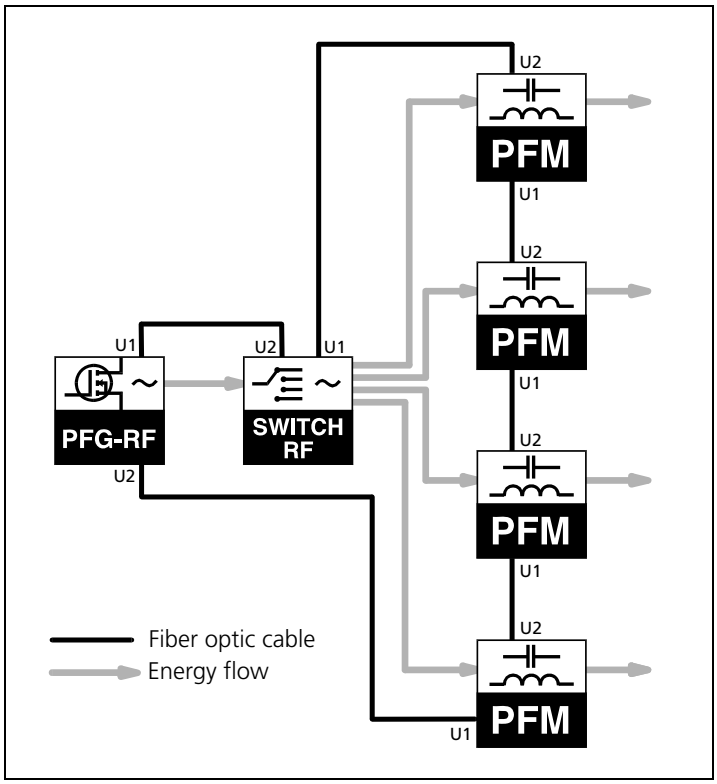


Fig. 8.13 Fiber optic cable In (U2), Out (U1)